POST NUBES LUX

THE COLLEGE OF AERONAUTICS

Cranfield · Bedfordshire

THE COLLEGE OF AERONAUTICS · CRANFIELD · BEDFORDSHIRE

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he rapid development and ever increasing complexity of aeronautical science demand the service of a constant flow of technicians and research workers possessing a sound knowledge of the special problems of this branch of engineering, and for this reason the establishment of an aeronautical College with wide facilities for theoretical and experimental study was thought by many to be a vital necessity in a country acutely concerned with aeronautical development for defence and commerce.

The idea of such a College originated with Sir Stafford Cripps when he was Minister of Aircraft Production. He referred the idea to the Aeronautical Research Committee, a body whose function is to advise the Government on scientific matters relating to aviation, and asked for their opinion. In 1943 the Committee submitted a confidential report in which the scheme was approved, and gave, in some detail, their views on the form which such a College should take and on the scope of its activities. The Minister then appointed an Inter-departmental Committee under the Chairmanship of Sir Roy Fedden to consider the project in much greater detail. This Committee reported in July 1944 and proposed the acquisition of a suitable airfield, on or near which a College, specially designed for its purpose and generously equipped, should be built. The circumstances prevailing at the time, however, made this scheme impracticable and, in order to avoid delay in the establishment of the College, a search was made for suitable existing accommodation. Eventually the Royal Air Force Station at Cranfield, Bedfordshire, was made available for the purpose, and the work of modifying the buildings to make them suitable for their new use commenced early in 1946. A short prospectus was prepared and circulated widely, to explain the aims of the College and to attract students, and the College was duly opened and commenced its teaching on October 15th, 1946.

At present the College is financed by His Majesty's Government through the vote of the Ministry of Education, but the policy control is in the hands of a Board of Governors, appointed by the Minister and representing a wide range of aeronautical interests. Detailed control is in the hands of a Senate, consisting of the Principal and the Heads of the teaching Departments.

The College provides a comprehensive education designed to fit its students for good positions in the aircraft industry, civil aviation, aeronautical research, the Services, and in the educational field,

with the hope that its best students will ultimately become leaders of aeronautical thought and practice.

The foundation of the teaching lies in a two-year Course at post-graduate level. In the first year the students, under the guidance of their Supervisors, select studies in various Departments so as to assure a broad knowledge of aeronautics, but with some consideration of their later specialisation. In the second year they spend most of their time in the Department in whose subject they wish to specialise but are free and are encouraged to continue studies in other Departments as far as their time will allow.

In the first year the mornings are in general devoted to lectures and the afternoons to practical work in the laboratories, drawing offices, and in flight. Great importance is attached to the thorough understanding of basic theoretical principles and, as will be apparent from the descriptions of the work of the Departments given later and from a study of the illustrations, a very comprehensive range of equipment enables the student to follow up the implications of theory by experiments related to most of the subjects taught. Because of the wide field to be covered, organised instruction occupies most of the available time.

The second year is very different in character. The student is required to prepare a thesis on a subject chosen in consultation with the academic staff, and to carry out some experimental research or undertake a piece of design work in addition, though this may well be related to his thesis subject. While the staff are prepared to give advice and guidance at any time, the student is encouraged to depend a great deal more on his own resources, and originality of thought is a major factor in the assessment of his work. The students frequently assist in the design, construction and setting up of apparatus required for special experiments which they wish to perform.

Successful students are awarded the Diploma of the College; outstanding merit is recognised by the addition of the words 'with Distinction'. The Diploma carries the right to the use of the letters D.C.Ae. after the holder's name.

Students are admitted by a Board of Entry, which bases its decision on the candidate's past record, supplemented by an interview when deemed necessary. The standard required is best described as that of a graduate in engineering, physics or mathematics, preferably with some practical engineering experience, but neither the possession of a degree nor the practical experience is obligatory. The Board of Entry makes its decisions entirely on its estimate of the candidate's ability to profit from the course.

So far, students fall into three main groups, those with primarily a University

background, those with an industrial apprenticeship and a Degree or a Higher National Certificate, and those who are serving Officers of the Royal Navy or the Royal Air Force. It is interesting to note that the best students of the year may come from any group. A practical engineering background is a great help, and appears often to balance the greater knowledge of general science and mathematics usually possessed by the University man. The original policy of the College not to insist on a degree as a necessary qualification for entry, despite the post-graduate nature of the course, has been thoroughly justified.

As soon as the two-year course had been firmly established consideration was given to the institution of shorter courses, usually of a week's or a fortnight's duration, in specific subjects for which there appeared to be a demand. A considerable number of such courses has now been held and some have been repeated. These courses are advertised from time to time in the technical press and applicants are admitted without any scrutiny by a Board of Entry.

It has always been recognised that original research is essential to the academic staff in a College such as this, and research is encouraged in every possible way. The College has inaugurated a series of reports in which the results of researches are presented, and in the first three years some thirty reports were produced. Students may assist in such research, and have, in some cases, been sole or joint authors of reports. The work carried out by students in their second year sometimes leads to research results of importance, and in this case an edited version of the thesis may be issued as a College Report. The existence of extensive engineering workshops for the construction and maintenance of College equipment is a great asset in connection with the preparation of special apparatus, either for student use or for staff research.

The College is still very young and it is perhaps early to speak of the future. The success of the College will be measured by the quality of its contribution to the supply of young technicians and research workers upon whom our position in the world of aeronautics must depend, and on its future ability to adapt and innovate in accordance with the needs of a science and an industry which are still in a state of very rapid development. The growth of the College itself has been very rapid and it would have been surprising if considerable difficulties had not been met. The fact that these have been largely overcome and the College brought to its present stage in so short a time gives confidence that it can and will fulfil its high aim of providing the finest education in aeronautical science in the world.

* *Staff of the College* *

Principal: ~~E. F. RELF, C.B.E., A.R.C.S., F.R.Ae.S., F.R.S.~~ Air Marshal Sir Victor Goddard

Deputy Principal: ~~Professor R. L. LICKLEY, B.Sc., D.I.C., M.I.Mech.E., F.R.Ae.S.~~

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Senior Lecturers: A. H. YATES, B.Sc., B.Sc.(Eng)., A.F.R.Ae.S. Performance, Stability and Control, Hydraulics.
S. KIRKBY, B.Sc., Ph.D., A.F.R.Ae.S. Mathematics. G. M. LILLEY, M.Sc., D.I.C., A.F.R.Ae.S. Aerodynamics.
Lecturers: A. W. BABISTER, M.A., A.F.R.Ae.S. Aerodynamics. W. S. D. MARSHALL, Dip.Aero.(Hull)., A.F.R.Ae.S. Aerodynamics.

Head of Department: Professor ~~R. L. LICKLEY, B.Sc., D.I.C., M.I.Mech.E., F.R.Ae.S.~~ W.S. Hemp. M.A. A.F.R.Ae.S. *Deputy Head of Department:* ~~Professor W. S. HEMP, M.A., A.F.R.Ae.S.~~ A.F. Newell.
Senior Lecturers: ~~A. F. NEWELL, A.M.I.Mech.E., A.F.R.Ae.S. Detail Design and Drawing Office.~~ S. V. COLBRAN, M.A. Instruments and Installations.
S. R. LEWIS, B.Sc., A.F.R.Ae.S. Aircraft Stressing. C. K. TROTMAN, B.Sc. (Eng). Structural Testing. P. L. TAYLOR, M.A. Radio and Electrical.
Lecturers: R. N. LORD, M.A., A.Brit.I.R.E. Radio and Electrical. K. H. GRIFFIN, B.Sc. Theory of Structures.

Head of Department: Professor J. V. CONNOLLY, B.E., F.R.Ae.S., M.I.Prod.E.
Deputy Head of Department: H. C. WILTSHIRE, M.Sc.(Eng)., M.I.Mech.E., M.I.E.E., M.I.I.A.
Senior Lecturers: J. CHERRY, A.M.I.Mech.E., A.M.I. Prod.E., A.M.I.I.A. Production Engineering, Jig and Tool Practice.
H. M. DAVIES, B.A. (Econ)., A.M.I.I.A. Cost Accountancy and Production Control. J. W. JONES, M.Sc. F.I.M. Materials and Metallurgy.
Lecturer: P. J. STANLEY, M.A., F.S.S. Statistics and Metrology.

Head of Department: Professor A. D. BAXTER, M.Eng., M.I.Mech.E., A.F.R.Ae.S. *Deputy Head of Department:* C. A. JUDSON, B.Sc., A.M.I.Mech.E.
Senior Lecturers: W. H. PASHLEY, B.Sc. (Eng). Power Plants and Accessories. Detail Design.
E. M. GOODGER, B.Sc. (Eng)., A.M.I.Mech.E., A.F.I.P., A.F.R.Ae.S. Combustion, Fuels and Oils. Thermodynamics.
A. BARKER, B.Sc. Rockets and Ramjets. J. R. PALMER, M.A. Theory and Performance.

Head of Department: Wing Commander C. G. B. McCLURE, A.F.C., B.A., A.R.Ae.S. *Deputy Head of Department:* I. A. ROBERTSON, D.F.C., A.R.Ae.S.
Senior Lecturer: C. F. BETHWAITE, B.Sc., A.F.R.Ae.S. Flight Experiments. *Flying Instructor:* B. F. RUSSELL. *Chief Aircraft Engineer:* A. FIRTH.
Chief Aircraft Inspector: W. T. ABBOTT.

Bursar and Deputy Registrar: P. R. R. STOCKS, A.C.A. *Resident Engineer:* D. GRUNDY, A.M.C.T. *Librarian:* C. W. CLEVERDON. *Assistant Registrar:* J. LYNALL.

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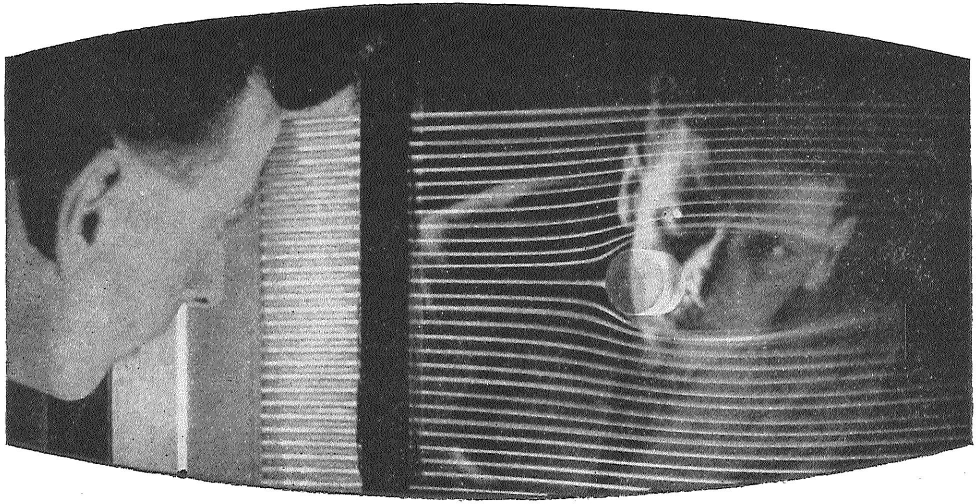


AERODYNAMICS

* FIRST YEAR

COURSE 'A'

KINEMATICS OF FLUIDS. DYNAMICS OF A FRICTIONLESS FLUID. VISCOSITY AND TURBULENCE. COMPRESSIBLE FLOW. AEROFOIL THEORY.

COURSE 'B'

GENERAL AERODYNAMICS. BOUNDARY LAYER THEORY. AERODYNAMICS OF PERFORMANCE. PROPELLERS. RELATIONS BETWEEN AERODYNAMIC FORCES AND MOMENTS AND MOTIONS OF AIRCRAFT. COMPRESSIBLE FLOW. CONTROL. STABILITY AND STABILISATION. FLUTTER AND DIVERGENCE.
HEAT TRANSFER.

MATHEMATICS

DETERMINANTS. DIFFERENTIAL CALCULUS. CO-ORDINATE GEOMETRY AND VECTOR ANALYSIS. FUNCTIONS OF A COMPLEX VARIABLE. DIFFERENTIAL EQUATIONS. FOURIER SERIES. CALCULUS OF VARIATIONS. STATISTICS. CALCULATING MACHINES.

MECHANICS

REVISION OF PRINCIPLES OF STATICS. PRINCIPLES OF DYNAMICS. RIGID DYNAMICS. ELEMENTS OF THE THEORY OF OSCILLATIONS. STABILITY.

LABORATORY WORK

WIND TUNNELS AND ANCILLARY APPARATUS. AERODYNAMIC CHARACTERISTICS OF LIFTING SURFACES. BOUNDARY LAYERS. PROPELLER CHARACTERISTICS. STABILITY AND CONTROL MEASUREMENTS. FLUTTER AND AERO-ELASTIC EFFECTS. HYDRAULICS. EXPERIMENTAL DYNAMICS. CALCULATING MACHINES.

AERODYNAMICS

SECOND YEAR

COURSE 'A' STABILITY AND CONTROL AND AEROELASTICITY.

COURSE 'B' AERODYNAMICS OF HIGH SPEED FLOW.

COURSE 'C' BOUNDARY LAYER THEORY FOR INCOMPRESSIBLE FLOW AND COMPRESSIBLE FLOW.

COURSE 'D' ADVANCED AEROFOIL THEORY.

COURSE 'E' MATRICES AND THEIR APPLICATION. THEORY OF OSCILLATIONS. FLUTTER.

COURSE 'F' DIFFERENTIAL EQUATIONS.

COURSE 'G' NUMERICAL MATHEMATICS. FUNCTIONS OF A COMPLEX VARIABLE. MATHEMATICAL STATISTICS.

COURSE 'H' SPECIAL LECTURES BY EXTERNAL LECTURERS.

COURSE 'I' AERODYNAMICS OF AIRSCREWS. ROTATING WING AIRCRAFT. TAILLESS AIRCRAFT. THEORY OF TURBULENCE. HEAT TRANSFER.

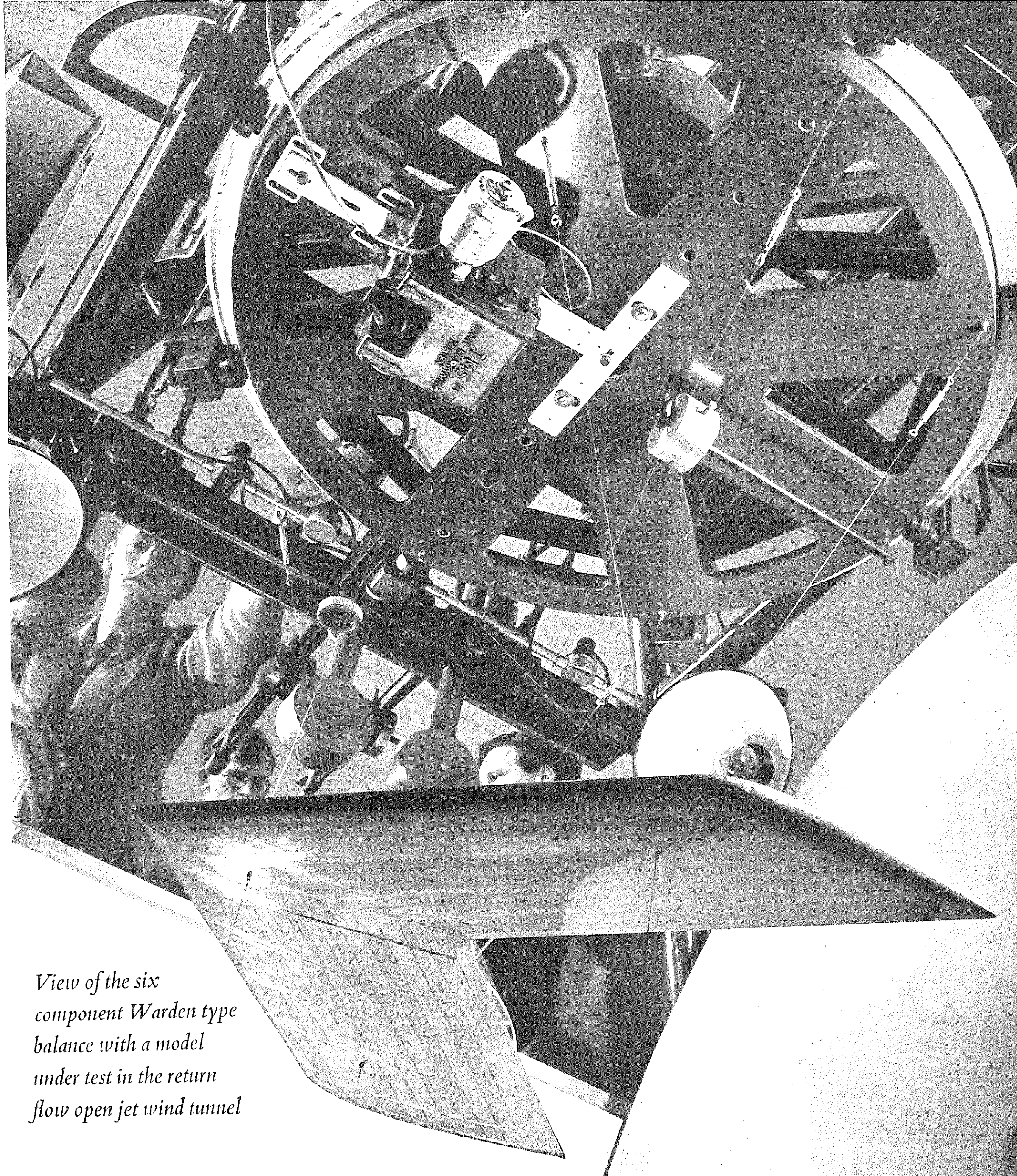
WIND TUNNEL EXPERIMENTS STABILITY AND CONTROL. BOUNDARY LAYERS. HIGH SPEED FLOW. EXPERIMENTAL RESEARCH ON PROBLEMS OF FUNDAMENTAL INTEREST.

n aircraft of whatever type moves in air and depends on the aerodynamic forces upon it for sustentation, propulsion and control. Thus, a thorough understanding of aerodynamic phenomena is essential for the rational design of aircraft. The science of Aerodynamics provides a systematic analysis of aerodynamic phenomena and is, therefore, a basic science of the first importance in aeronautics. Since, however, the aircraft itself is constructed from solid materials, the basic science of mechanics is of equal importance with aerodynamics. The aim of the teaching in the Department of Aerodynamics is to provide the student with a good knowledge and grasp of aerodynamics and mechanics, together with the background of mathematics on which both these sciences largely depend. All students taking the two-year course receive instruction in these subjects during their first year and those who wish to

specialise in aerodynamics, with a view to a career in industry or research, continue these studies at a higher level in their second year.

Instruction is provided in the three subjects of Aerodynamics, Basic Mechanics and Mathematics. Mathematics and Mechanics are essential background subjects for the teaching throughout the whole College. They are taught with the twin aims of fitting the student to apply them in his daily work and to enable him to understand and appreciate the scientific and technical literature of aeronautics. Special attention is given to numerical mathematics, which is of growing importance in both industry and research. Statistical mathematics is likewise finding many new applications in aeronautics and receives due attention in the Department.

Aerodynamics is the science which deals with the motion of gases of all kinds and with the forces on bodies



View of the six component Warden type balance with a model under test in the return flow open jet wind tunnel

immersed in them. In its aeronautical application, special importance attaches to aircraft performance and control and to the attainment of safety in flight. The last requires the study of the stability of aircraft and of the means for the prevention of troubles such as flutter. Aerodynamics also enters into problems of propulsion, in an obvious way when the aircraft is propelled by airscrews, but to a no less important extent with jet propulsion. The correct proportioning and shaping of the parts of an aircraft and the provision of adequate strength and stiffness to withstand the aerodynamic loads are the principal problems of Aircraft Design and the solution of all of these depends on knowledge of aerodynamics. Special difficulties arise when the speed of flight approaches or exceeds the velocity of sound in the surrounding air on account of important changes in the air flow about the aircraft. Further troubles arise in high speed flight on account of the distortion of the structure and the modification of the aerodynamic forces which this entails. All these questions receive much attention in the Department.

Teaching is given in lectures, exercise classes and in the laboratories. There is also a considerable amount of individual instruction, especially in the student's second year. The examples and exercises set for the students are designed to help them to attain a real grasp of their subjects. Much importance is attached to the preparation of good reports on experimental work and instruction on the writing of reports is given.

Great emphasis is placed on the importance of experimental work in the laboratories of the Department and in flight; the latter is arranged in collaboration with the Department of Flight. The students are given great freedom to use the equipment of the Department and their experimental initiative is encouraged in every way. In addition to writing a thesis, second-year aerodynamic specialists all carry through a special piece of experimental work and prepare a report upon it. The importance of practical work is also recognised in the provision of laboratories in hydraulics, dynamics and numerical mathematics in addition to the aerodynamic laboratories.

The staff of the Department are encouraged to carry on researches themselves and to interest the students in research. Already a number of research papers have been published in the series of College of Aeronautics Reports and elsewhere. Students of the College have collaborated in several of the researches and have contributed to the College Reports. It is hoped to extend this work with the help of research assistants and post-diploma students.

A close and continuing contact with Industry, the Universities and Research Establishments is maintained. Visits by the staff to Universities, Colleges, Lab-

oratories and the Industry abroad are encouraged.

The main equipment of the Department is summarised below:

LOW-SPEED WIND TUNNELS AND BALANCES

3 ft. by 3 ft. closed working section, straight-through tunnel. Maximum speed 120 ft./sec.

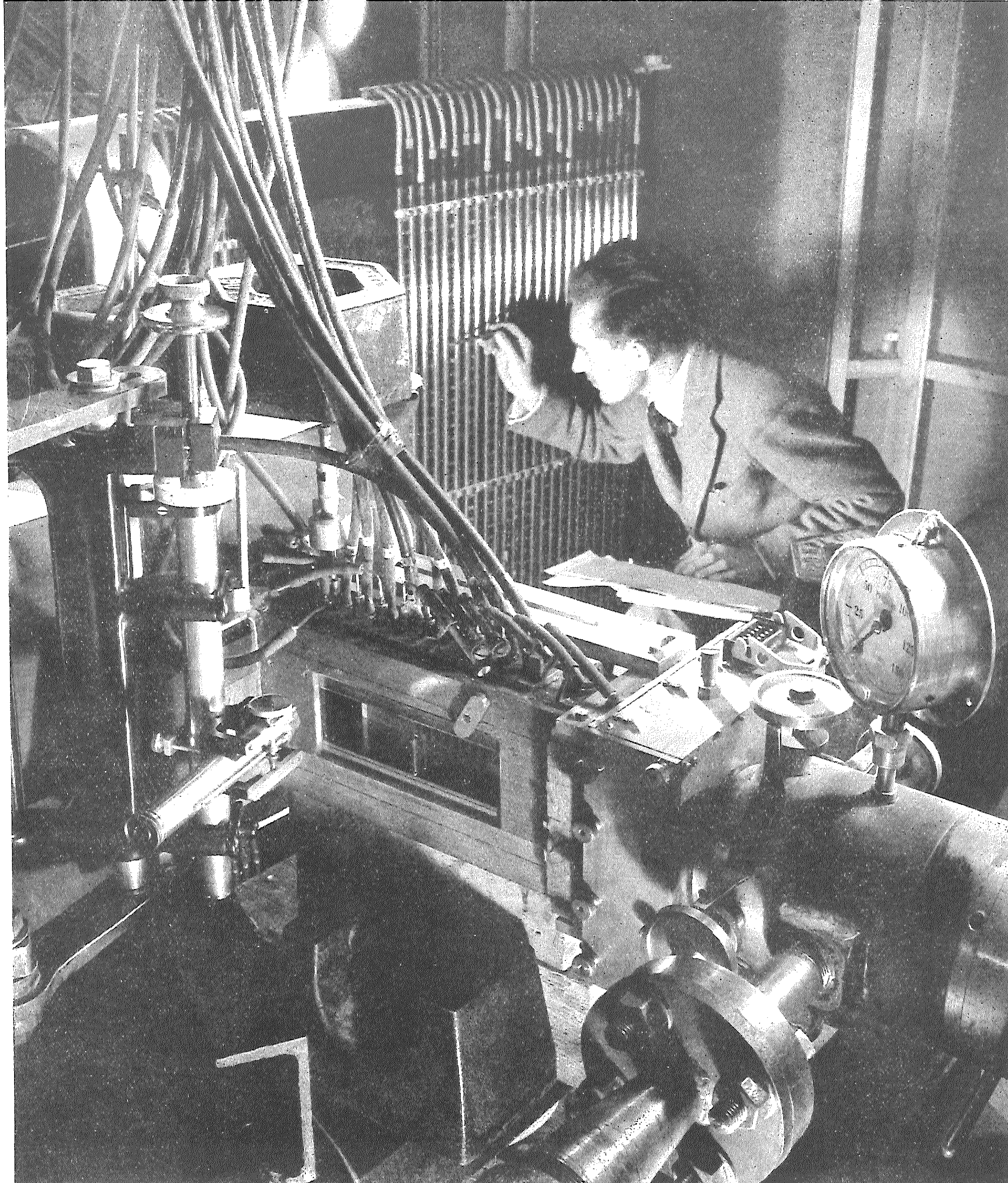
Return flow open jet circular wind tunnel. Diameter 3 ft. 6 in. Maximum speed 140 ft./sec.

Warden type 6-component balance.

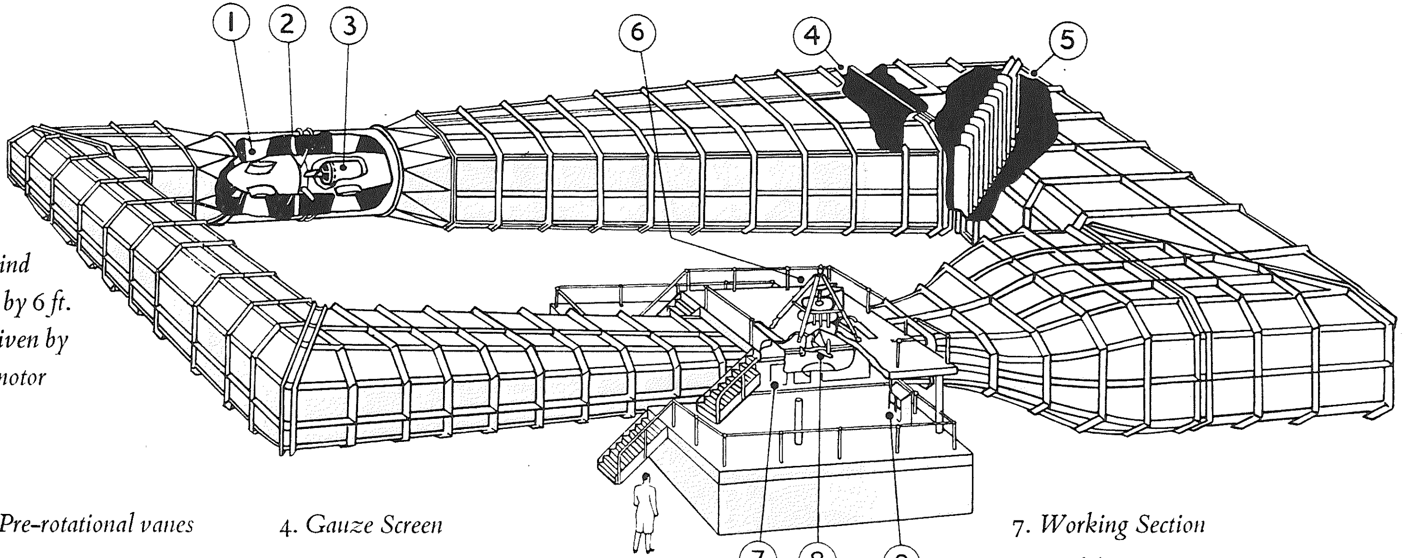
Return flow open jet wind tunnel with twin elliptic working sections, 3 ft. 6 in. by 2 ft. 3 in. Maximum speed 130 ft./sec.

One lift, drag and pitching moment balance.

One lift and drag balance.



Investigating the pressure distribution in the working section of a small induction type supersonic wind tunnel



General purpose wind tunnel, having 8 ft. by 6 ft. working section, driven by a 500 h.p. electric motor

1. *Pre-rotational vanes*
2. *Fan*
3. *Fan Motor*
4. *Gauze Screen*
5. *Corner Vanes*
6. *Six-component Balance*
7. *Working Section*
8. *Model*
9. *Control Desk*

N.P.L. type non-return tunnel. Closed working section, breadth 1 ft. 4 in., height 2 ft. 4 in. Maximum speed 240 ft./sec.

Blower tunnel with lift, drag and pitching moment balance.

Low turbulence tunnel having closed working section with pressurised observation chamber.

Blower tunnel for testing cascades of aerofoils.

Large general purpose wind tunnel, closed working section 8 ft. by 6 ft., maximum speed 300 ft./sec., provided with six component balance. (under construction).

HIGH-SPEED TUNNELS

Continuous return flow high-speed tunnel with working section 9 in. sq. for subsonic and supersonic tests up to a Mach number of 2.5.

$2\frac{1}{2}$ in. sq. high-speed intermittent tunnel for supersonic speeds up to a Mach number of 3.

Two 2 in. sq. induction type tunnels for subsonic and supersonic tests up to a Mach number of 1.8.

Compressor delivering 45 lb. of air per minute at 100 lb./sq. in. for high-speed experiments in pipes and channels.

SMOKE TUNNELS

Lippisch smoke tunnel.

Rectangular working section, height 3 ft. 3 in., width 2 in. Maximum speed 40 ft./sec.

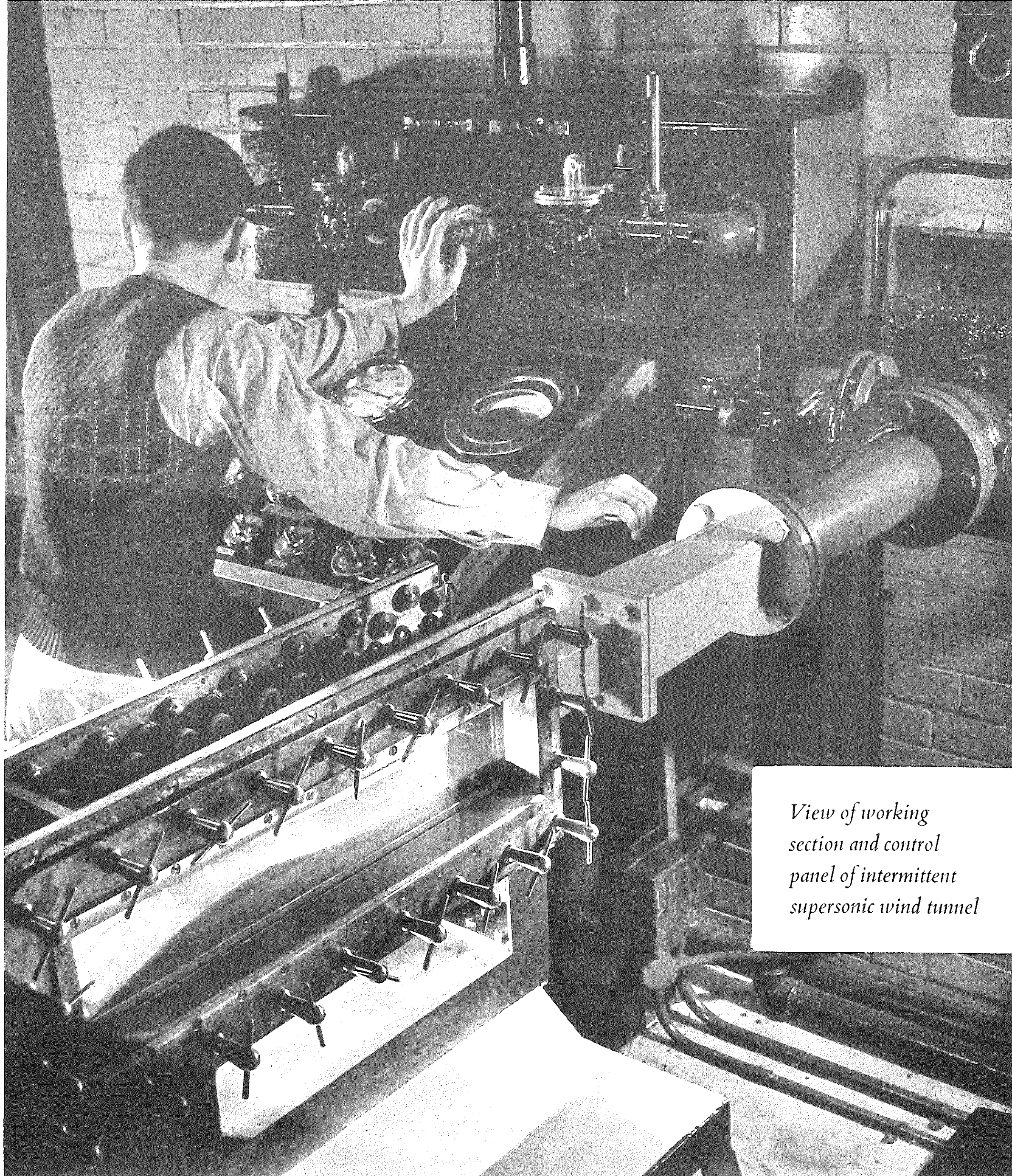
Small smoke tunnels (two).

Rectangular working section, height 11 in., breadth 1 in. Maximum speed 6 ft./sec.

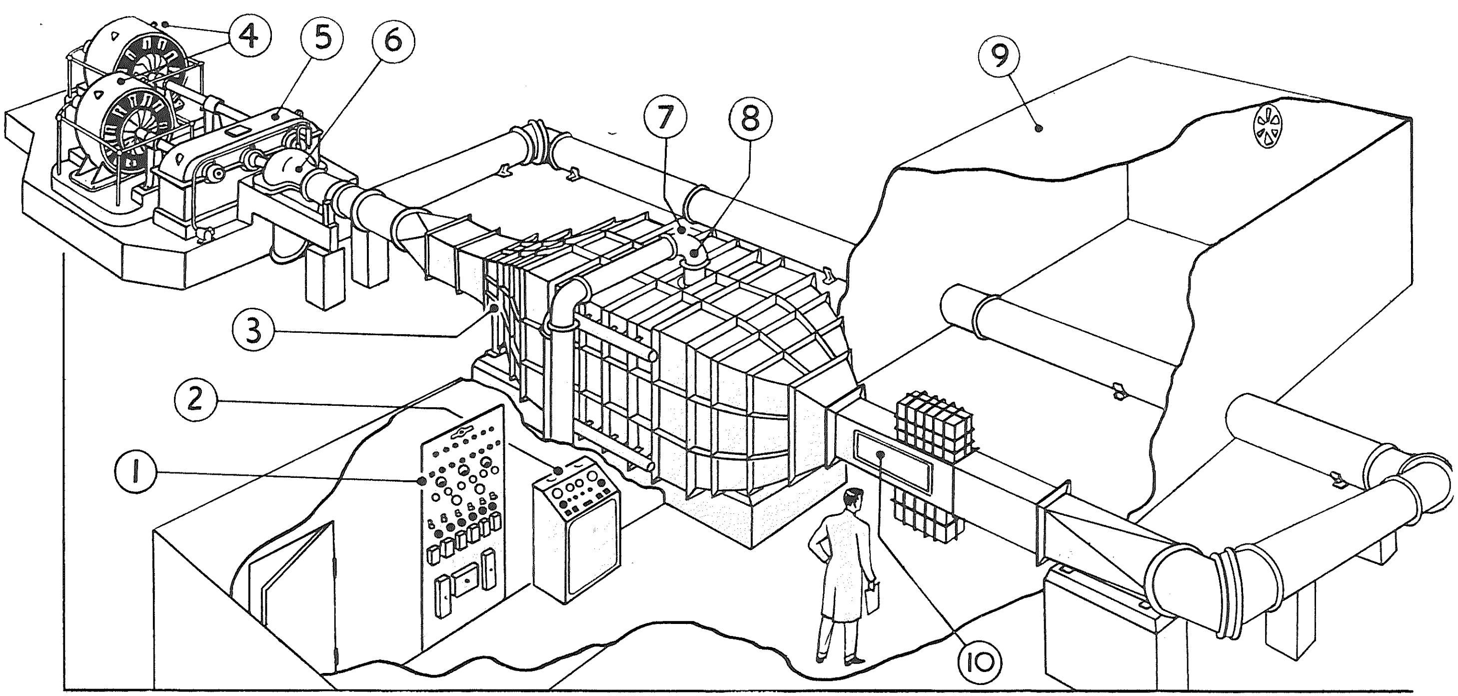
Farren type smoke tunnel arranged for projection, working section 3 in. by 3 in.

MISCELLANEOUS EQUIPMENT

There are also several small demonstration tunnels, blower test rigs etc., and numerous models of complete aircraft, wings and components, including special purpose models. All the main types of instruments for measuring air velocity, pressure and turbulence are held



View of working section and control panel of intermittent supersonic wind tunnel



Continuous running return flow supersonic wind tunnel having 9 in. square working section. The axial compressor is driven by two electric motors each of 550 h.p.

1. *Instrument panel*
2. *Control Desk*
3. *Rapid Expansion*
4. *Motors*
5. *Gear Box*
6. *Compressor*
7. *Cooler Section*
8. *Vacuum Pump Connection*
9. *Observation Room*
10. *Working Section*

by the Department, as well as boundary layer traversing gear and apparatus for experiments in flight.

THE HYDRAULICS LABORATORY

For experiments on the flow of liquids, water is supplied to the laboratory from a 6,000 gallon tank at a head of about 25 ft. It drains from the laboratory into an underground sump, from which it is pumped back into the tank.

The apparatus includes open channels for the study of surface waves, flow over weirs and under sluices, hydraulic jumps and the analogy with flow of a compressible fluid. Flow pressure losses resulting from bends and rough pipes can be measured in other apparatus.

Flow patterns round aerofoils, cylinders etc., can be made visible by filaments of dye in the water or powder sprinkled on its surface. The transition from laminar to turbulent flow can be demonstrated. Viscometers of various types are included in the equipment.

THE DYNAMICS LABORATORY

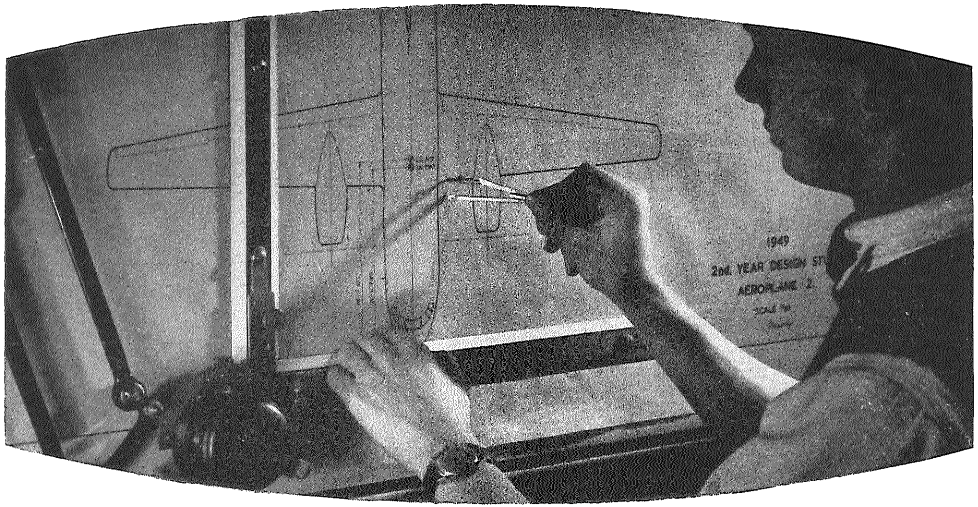
Full facilities for teaching and research in Dynamics include apparatus for demonstrating the fundamental principles of Mechanics, especially gyroscopic effects and the principles of momentum. For experimental research in vibrations there is an extensive range of electronic gear, comprising exciters and recording apparatus with which transient and steady-state phenomena can be investigated in the frequency range 1 to 10,000 cycles per second. This equipment, which is of new design, has been developed and constructed in the College.

THE COMPUTING LABORATORY

A number of calculating machines is installed for instruction and numerical work. Of varying complexity, they include simple hand-operated and fully automatic models of the latest design. Among the other instruments are planimeters of various types, integraphs, a small differential analyser and a harmonic analyser.

Some of the electrical calculating machines and ancillary equipment of the Computing Laboratory

T H E D E P A R T M E N T O F



A I R C R A F T D E S I G N

* FIRST YEAR

ELEMENTARY ELASTICITY & STRUCTURES (*30 lectures*)

Theory of Stress and Strain in two dimensions : STRAIN ENERGY. ELEMENTARY EXACT SOLUTIONS. BENDING BY COUPLES, BENDING OF FLAT PLATES, ETC.

Methods of Structural Analysis: SOUTHWELL'S METHOD. CONSEQUENCES OF HOOKE'S LAW. PRINCIPLES OF MINIMUM ENERGY. STIFF JOINTS.

Stability of Equilibrium: METHODS OF ANALYSIS. RAYLEIGH'S METHOD. APPLICATION TO STRUTS, ETC.

STRESS ANALYSIS (*30 lectures*)

STRESS-STRAIN RELATIONSHIPS FOR AIRCRAFT MATERIALS. BOLT AND RIVET GROUPS. CONTINUOUS BEAMS. ANALYSIS OF BOOMS AND WEBS. ENGINE MOUNTING ANALYSIS. TIES AND STRUTS.

DETAIL DESIGN (*30 lectures*)

TYPES OF CONSTRUCTION. METHODS OF FABRICATION. JOINTS. MECHANISMS. CONTROLS. SEATS AND COCKPITS. POWER PLANT INSTALLATIONS. LOFTING. WEIGHT ANALYSIS. PRACTICAL DRAWING OFFICE WORK (50 HOURS) TO ILLUSTRATE THESE PROBLEMS.

INSTALLATIONS AND INSTRUMENTS (*30 lectures*)

METHODS OF ACTUATION. THE AIRCRAFT ELECTRICAL SYSTEM. AIRCRAFT INSTRUMENTS. AUTOMATIC PILOTS. FIRE PREVENTION AND PROTECTION. HIGH ALTITUDE FLYING. DE-ICING.

BASIC COURSE (*30 lectures*)

TYPES AND DESIGN OF AIRCRAFT. REGULATIONS AND REQUIREMENTS. CONSTRUCTION OF UNITS. PROBLEMS OF ACTUATION AND INSTRUMENTS. TESTING OF AIRCRAFT.

Practical work in the laboratories and the demonstration hangar is closely linked throughout the year with the above lectures.

SECOND YEAR

OVERALL DESIGN PROBLEMS (*30 lectures*)

THE START OF A DESIGN. PROJECT STUDIES. USE OF WIND TUNNEL DATA. CHOICE OF WING SECTION. SPECIAL PROBLEMS OF MILITARY AND OF CIVIL AIRCRAFT. TYPES OF CONTROL SURFACES. CHOICE OF POWER UNIT. METEOROLOGICAL EFFECTS ON DESIGN. EFFICIENCY OF AIRCRAFT. FLIGHT TESTING IN RELATION TO DESIGN. WRITING OF SPECIFICATIONS.

STRUCTURAL DESIGN (*30 lectures*)

THE WEIGHT PROBLEM: USE OF SPECIAL MATERIALS AND CONSTRUCTION. INABILITY TO USE PERFECT STRUCTURES. TYPES OF STRUCTURES AND METHODS OF CONSTRUCTION: WINGS, FUSELAGES, TAIL UNITS, LANDING GEAR, ENGINE INSTALLATIONS. FLYING CONTROLS. FLYING BOATS.

continued overleaf

AIRCRAFT DESIGN

SECOND YEAR *continued*

LOADING AND REQUIREMENTS (*15 lectures*)

EXISTING REQUIREMENTS. DEVELOPMENT OF LOADING SYSTEMS. STIFFNESS AND OTHER AEROELASTIC REQUIREMENTS. EFFECT OF SIZE. STATISTICAL ANALYSIS OF LOADING. EFFECT OF REPEATED LOADS. WEIGHT CONTROL AND MECHANICAL TESTING IN RELATION TO REQUIREMENTS.

STRESS ANALYSIS (*30 lectures*)

An extension of the First year course linked with practical design work and with 'Loading and Requirements'.

STRESS DISTRIBUTION AND DEFLECTION PROBLEMS (*30 lectures*)

SIMPLIFIED THEORY OF REINFORCED PLATES AND SHELLS.
GENERAL THEORY OF PLATES AND SHELLS.
THREE DIMENSIONAL THEORY OF ELASTICITY. PLASTICITY.

ELASTIC STABILITY & LARGE DEFLECTION PROBLEMS (*30 lectures*)

THIN RODS. FLAT PLATES. CURVED SHELLS.

DYNAMICAL PROBLEMS (*15 lectures*)

FUNDAMENTALS AND METHODS. VIBRATION OF CONTINUOUS BODIES AND STRUCTURES. APPLICATIONS.

INSTALLATION PROBLEMS (*As required*)

PRESSURISATION AND AIR CONDITIONING. COCKPITS. ACTUATION.
RADIO AND RADAR INSTALLATION.

he words 'Aircraft Design' convey to a reader very little of the complexity and range of subjects which are now involved in the design of an aeroplane. These subjects include, for example, applied aerodynamics, mechanical problems such as pressurising, and operating problems such as the design of airliner kitchens. No course can hope to cover every detail in this wide field. The field has accordingly been narrowed to cover initial design, structural design (including stressing), detail design (including drawing office work) and installation and instrumentation work.

The aim of the department is to give such theoretical and practical training to students as will enable them to acquit themselves satisfactorily in any of the major branches of aircraft design. To this end a comprehensive series of lectures is given in those branches, together with practical design work in the Drawing Office, and extensive training in experi-

(5) A drop test rig for studying undercarriage performance.

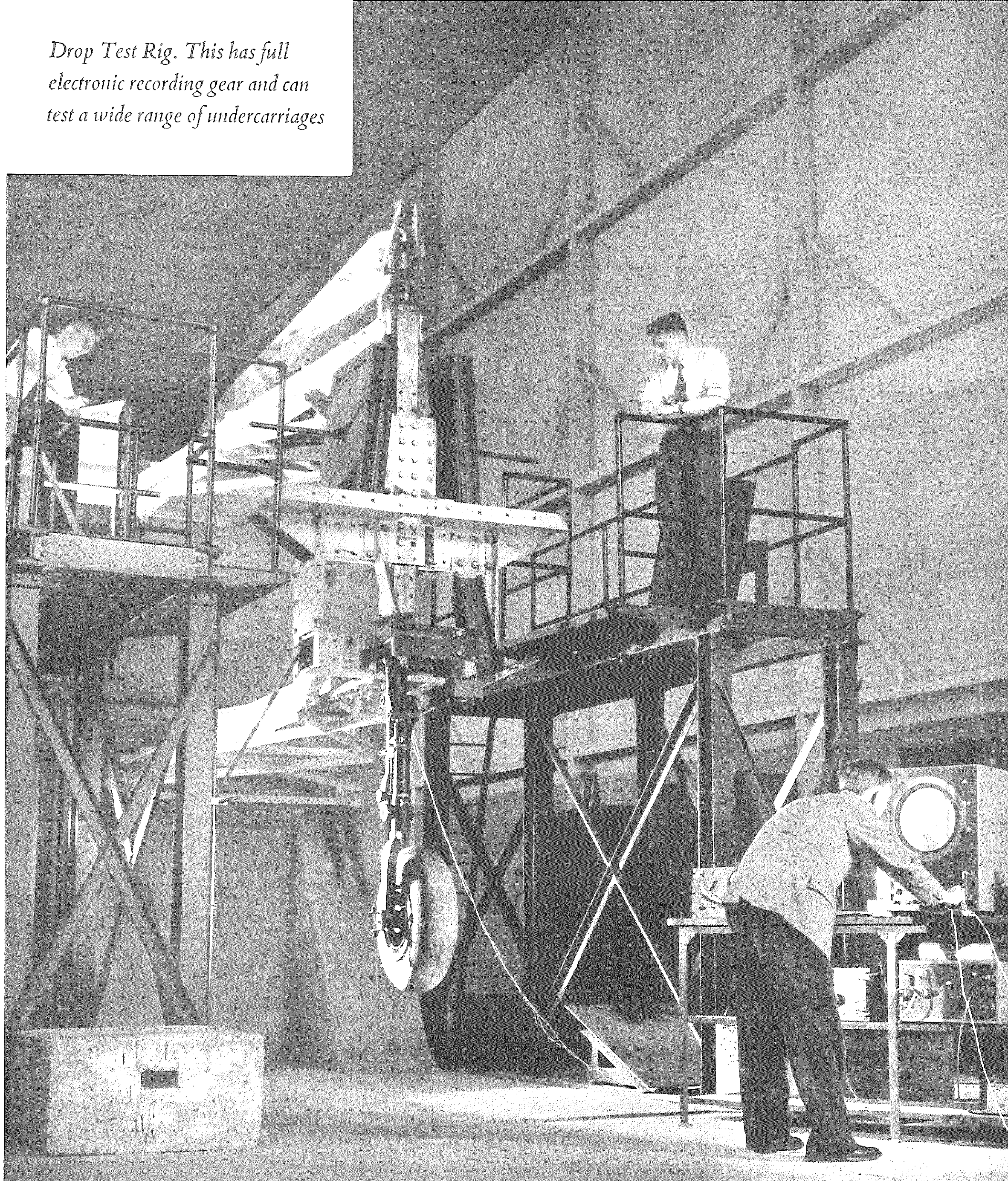
(6) A water tank for developing the technique of pressure testing of structures under water.

(7) An optical bench for photo-elastic work.

(8) Apparatus for determining modes of vibration and frequency response of dynamic models and full scale aircraft.

(9) Modern apparatus for measuring strains and deflections is available to aid the above tests and is undergoing continual development.

THE INSTRUMENT LABORATORY contains a complete range of flying instruments together with vacuum chambers, gyro test benches and other test equipment to enable the student to examine their performances. The principles of the gyro types of instrument, demonstrated both by models and actual instruments, lead in their turn to the handling of an auto-pilot and the principles of automatic control. Both air and electrically operated instruments are

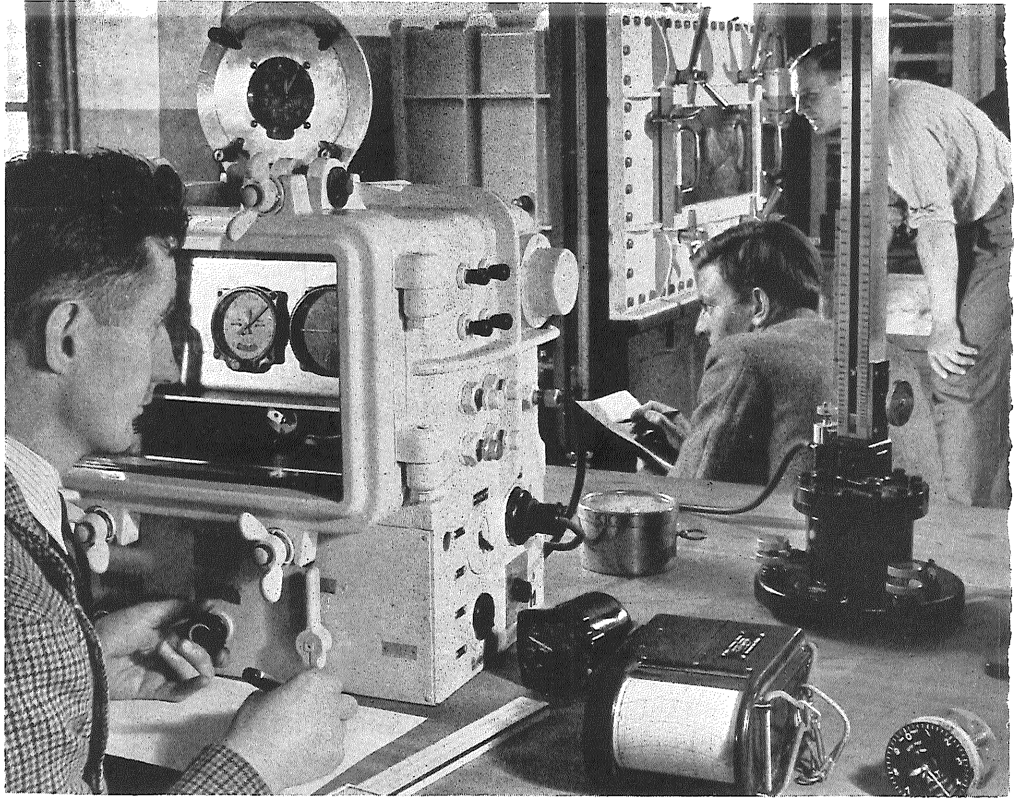


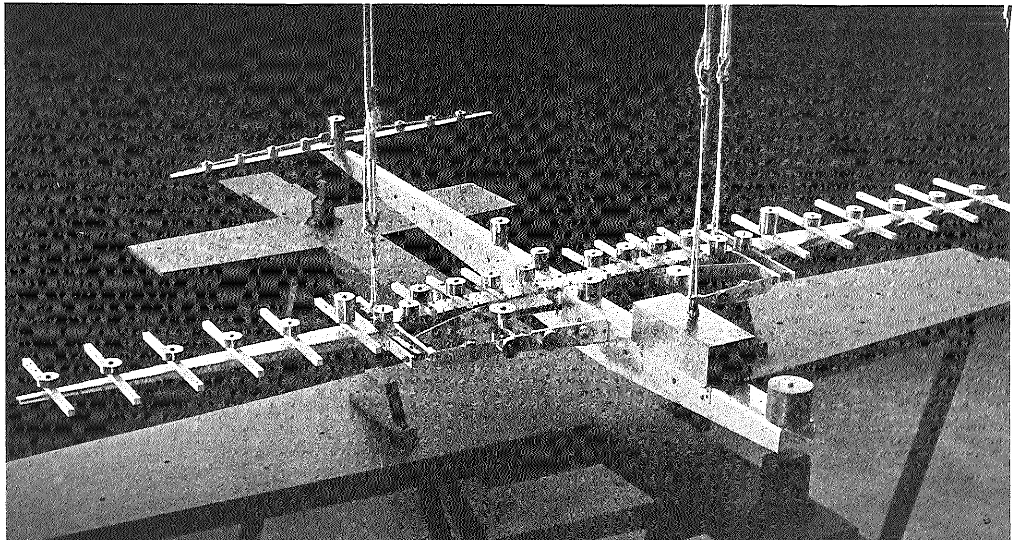
Drop Test Rig. This has full electronic recording gear and can test a wide range of undercarriages

dealt with and the various remote indicating systems are covered in detail. There are also two altitude chambers for the study of pressurisation and instrument problems. The larger of these is $11\frac{1}{2}$ ft. by $6\frac{1}{2}$ ft. by 6 ft. and can be evacuated to an equivalent altitude of 50,000 ft., permitting many problems of high altitude performance to be studied in detail.

THE INSTALLATION LABORATORY has representative hydraulic, electric and pneumatic systems of actuation set up to give the student first-hand knowledge of the installational problems and capabilities of each type.

THE DEMONSTRATION SECTION presents students with a unique opportunity to make detailed examination of, and tests on, a variety of recent aircraft selected to show up-to-date practice. Students, especially those without pre-



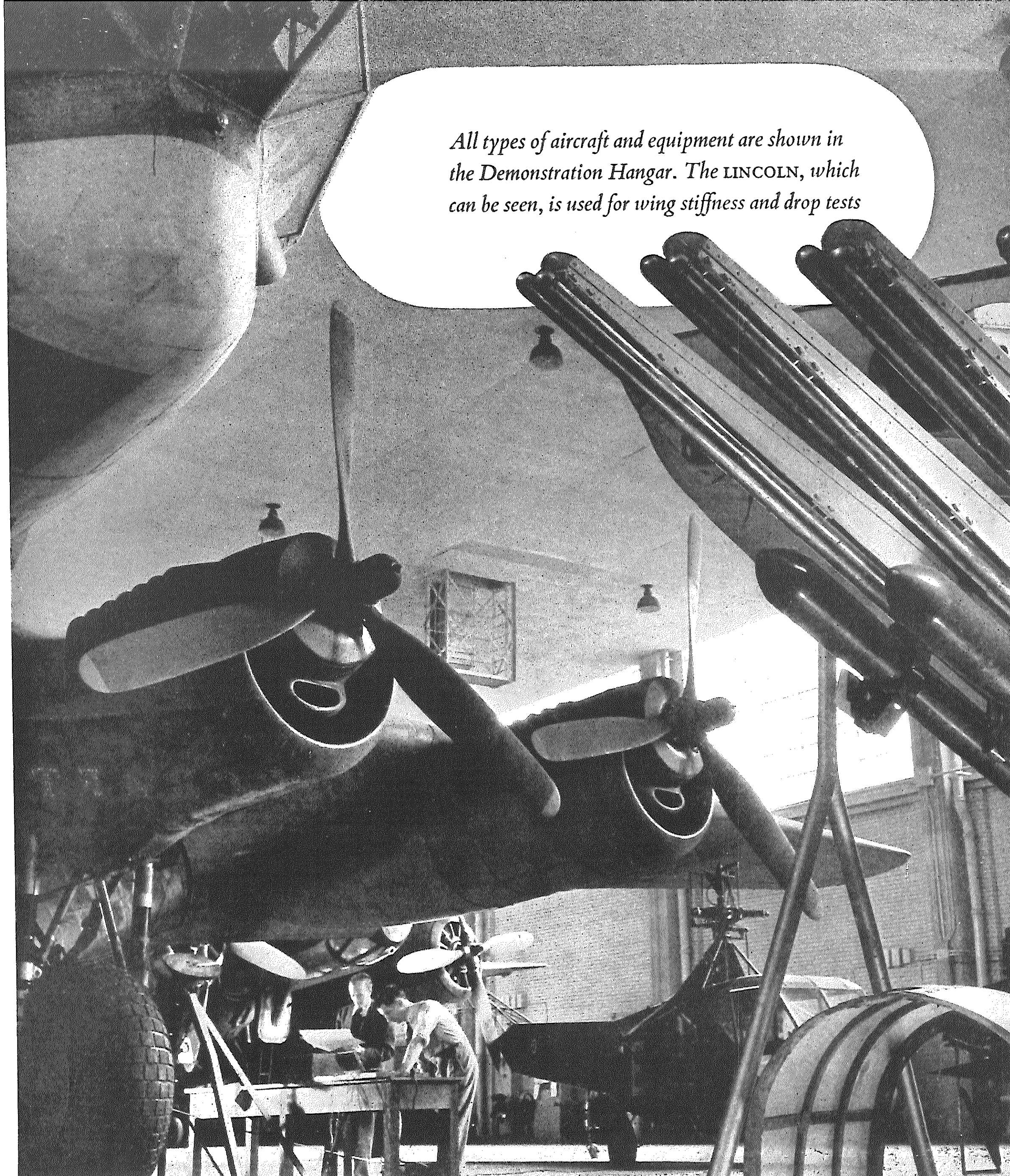


(ABOVE) *A corner of the Instruments Laboratory showing vacuum chambers*

(BELOW) *Problems of dynamic loading are solved by the use of models. A model for vibration tests*

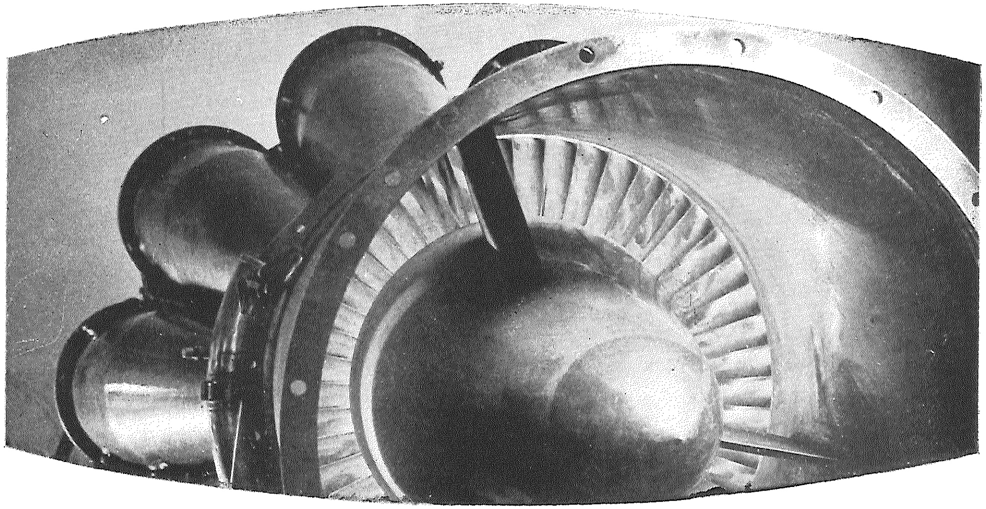
vious aircraft experience, gain by this means a realisation of the complexity of the modern aeroplane, while at the same time carrying out full-scale wing stiffness tests, vibration surveys and thesis work of varying types. Sectioned units and aircraft parts are used in conjunction with the design and drawing office work to give the student help in tackling his designs.

Finally, in conjunction with all the other facilities and giving the student a chance to put on paper what he has learnt or seen, is the *DRAWING OFFICE*. The student's time here forms a background to his whole period in the department, and the specialist will spend upwards of 250 hours here during the two-year course. The offices cover approximately 2,200 sq. ft. and compare favourably in lighting and equipment with any drawing offices in the aircraft industry; students are given experience of both drawing board and draughting machine methods.



All types of aircraft and equipment are shown in the Demonstration Hangar. The LINCOLN, *which can be seen, is used for wing stiffness and drop tests*

THE DEPARTMENT OF



AIRCRAFT PROPULSION

* FIRST YEAR

COURSE 'A'

THERMODYNAMICS. THEORY AND PERFORMANCE OF PISTON ENGINES. COMBUSTION AND DETONATION. FUEL METERING SYSTEMS. POWER BOOSTING SYSTEMS. ENGINE TESTING AND DEVELOPMENT. FUELS AND OILS. LUBRICATION.

COURSE 'B'

DETAIL DESIGN PROBLEMS. POWER PLANT INSTALLATIONS AND ACCESSORIES. PROPELLERS ETC. GAS TURBINE FUEL AND OIL SYSTEMS. HEAT EXCHANGERS AND RADIATORS.

COURSE 'C'

PROPULSIVE SYSTEMS, GENERAL PRACTICE AND FUTURE TRENDS. FACTORS INFLUENCING THE DESIGN OF PISTON ENGINES AND GAS TURBINES. GENERAL VIBRATION PROBLEMS. DESIGN AND CONSTRUCTION OF PISTON ENGINES AND GAS TURBINES.

COURSE 'D'

GAS DYNAMICS. THEORY AND PERFORMANCE OF GAS TURBINES. CHARACTERISTICS OF COMPRESSOR, TURBINE AND JET PIPE. EQUILIBRIUM RUNNING OF GAS TURBINES. HEAT EXCHANGER THEORY. THEORY AND PERFORMANCE OF RAM JETS AND ROCKETS.

BASIC COURSE

BASIC THERMODYNAMICS AND GAS DYNAMICS. PROPULSIVE SYSTEMS AND TRENDS. THEORY OF VARIOUS POWER UNITS AND OUTSTANDING DESIGN FEATURES. FUELS AND OILS. POWER PLANTS AND INSTALLATION PROBLEMS. PROPELLERS. TESTING AND DEVELOPMENT PROBLEMS.

LABORATORY WORK

FULL SCALE ENGINE TESTING. ENGINE COMPONENT AND ACCESSORY RIG TESTING.
DETERMINATION OF COMPRESSOR CHARACTERISTICS.
FUEL TESTING AND KNOCK RATING.
FUEL METERING. EXHAUST GAS SAMPLING AND ANALYSIS. COMBUSTION AND COMBUSTION CHAMBER TESTING. DETERMINATION OF STRESSES IN ENGINE COMPONENTS UNDER STATIC AND DYNAMIC LOADS. VIBRATION OF ENGINE COMPONENTS. TESTING OF HEAT EXCHANGERS. DESIGN WORK ON ENGINES AND THEIR COMPONENTS.

SECOND YEAR

In the Second Year, the subjects outlined in the First Year Courses A, B, C and D are considered in more detail and in more advanced aspects. In addition, the following further courses are given:

COURSE 'E'

AXIAL COMPRESSOR THEORY. ECONOMICAL GAS TURBINES AND COMPOUNDED ENGINES.

COURSE 'F'

GENERAL DESIGN PROBLEMS. ENGINE STRESSING.

COURSE 'G'

LECTURES ON SPECIALIST SUBJECTS BY VISITING LECTURERS.

he development of jet propulsion and its application in various forms to aircraft power units profoundly affects the field of enquiry covered by this Department. The shortage of technicians and research workers to exploit the new types of power plant means that there are great opportunities for those who enter the industry with a sound training.

Nevertheless, because the piston engine is considered likely to play a large part in aviation for some time yet, great care has been taken to provide a course giving a balanced outlook to meet the demands and difficulties of a transitional period. This is the object of the Department, both for those who will specialise elsewhere, and in much greater detail for those who choose propulsion for their future career.

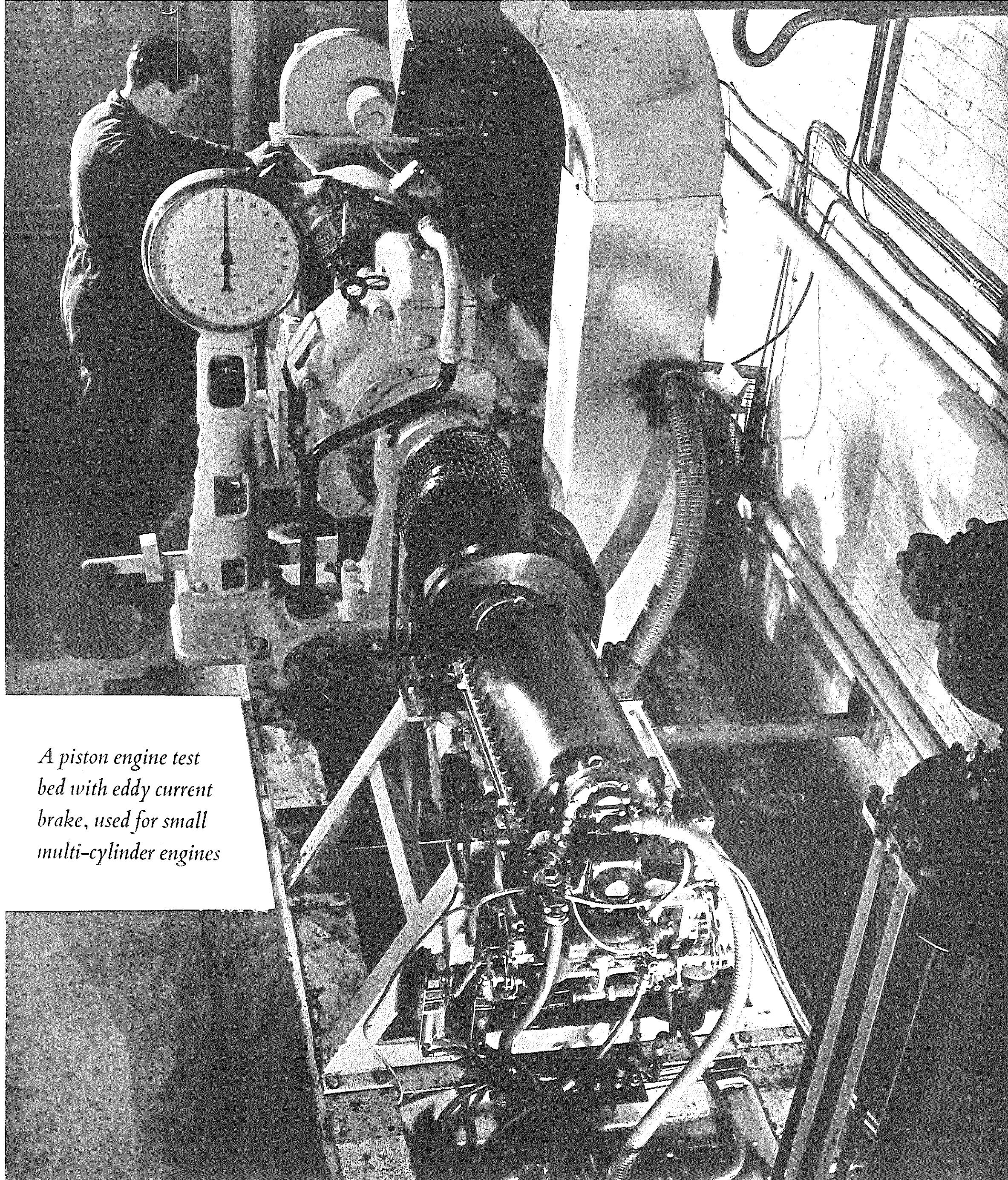
A Basic Course parallel with those of the other main departments is attended by all students not specialising in Propulsion. This covers the essentials of the subject as set out in the abbreviated syllabus. Students who take Propulsion as a main subject, however, attend four lectures a week in the first year, and carry out representative series of experiments in the laboratories. The second year comprises some seven or eight lectures a week and includes lectures by specialists from the aero-engine industry and from the research establishments. These men, because of their active participation in the nation's industrial and research programmes, bring with them an awareness of current affairs, which it is the constant aim of the teaching staff to foster. Another valuable link with current developments is provided by visits to leading firms and research estab-

lishments. These are encouraged by the organisations themselves, and each year a representative number of visits is arranged.

The students, in preparing theses, are also encouraged to follow up their research work by personal consultations with the appropriate specialists in industry and elsewhere, and the Department directly assists in effecting these introductions, which have proved to be a successful feature of student education.

The Department's activities with engine types of the future, such as ramjets and rockets, have been arranged to provide a balanced syllabus in the time available. These prime movers form a unique field for research, in which the Department's plant, though necessarily limited, can do valuable work.

In cases where the necessary equipment is not available in the College, the course is supplemented by visits to estab-



A piston engine test bed with eddy current brake, used for small multi-cylinder engines

lishments possessing such apparatus, and the students thus obtain first-hand information on the work that is going forward and the specialised equipment required.

There are certain basic fields of enquiry covering the theoretical investigation of air flow, fuels and combustion, and the more recent types of power unit permit a much closer correlation between theory and experiment than does the piston engine. Such basic work involves some of the pure and applied sciences, such as aerodynamics for the behaviour of cascades of blades in turbines and compressors, gas dynamics and chemistry for the combustion process, and thermodynamics since all these prime movers are heat engines.

It is by this approach that the students are led to an appreciation of the special problems of the piston engine, gas turbine, rocket and ram-jet. Laboratory courses include, as far as possible, experiments illustrating the fundamentals of the subject, as well as tests on engine components and accessories, and on the complete power unit. These are augmented by appropriate experiments on propulsion units in the Department of Flight.

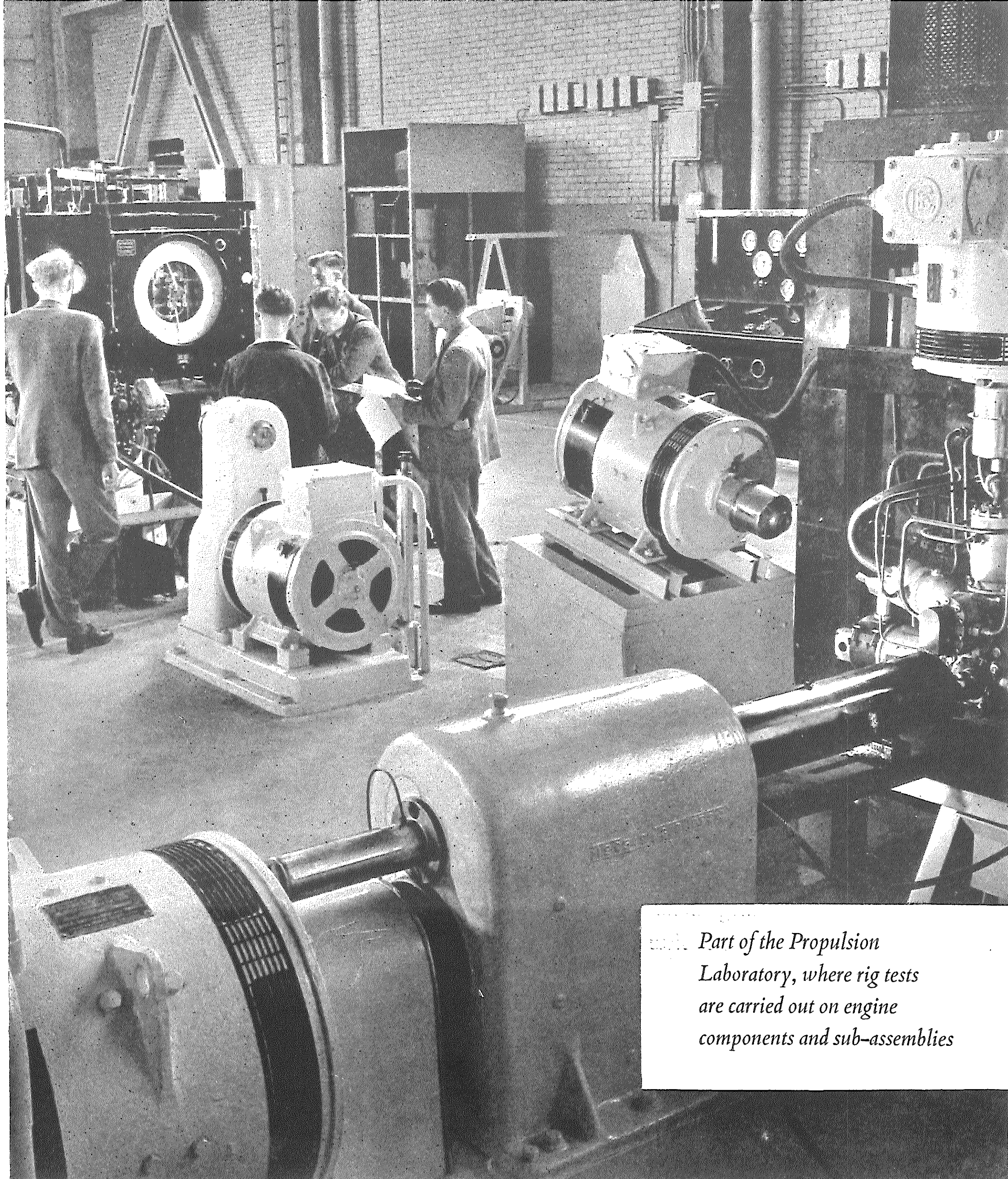
On the design and development side the course includes the general principles of engine design with practical examples taken from typical piston engines and gas turbines. Stressing, detail design and general development problems are also considered and a proportion of the afternoon periods are devoted to work in the Drawing Office. The first-year work attempts to give the students some preliminary design experience and in the second year, the students, working as a team, investigate the design of a specific gas turbine and prepare design schemes of the major assemblies, the work being carried through on the lines of a professional drawing office. Firms specialising in propellers or power plant accessories are consulted for details of appropriate components and, where possible, the calculations are checked by suitable rig tests.

Although time is available for each student to design only one part of the engine, students are encouraged to discuss their schemes with each other and tutorials are arranged so that any outstanding problems are considered by all the students as a body. The aim here is to teach the students to think for themselves and produce original designs which are perfectly sound and practical. It is appreciated that, in the time available, the students cannot produce complete schemes for a new engine but they can go a long way towards doing this.

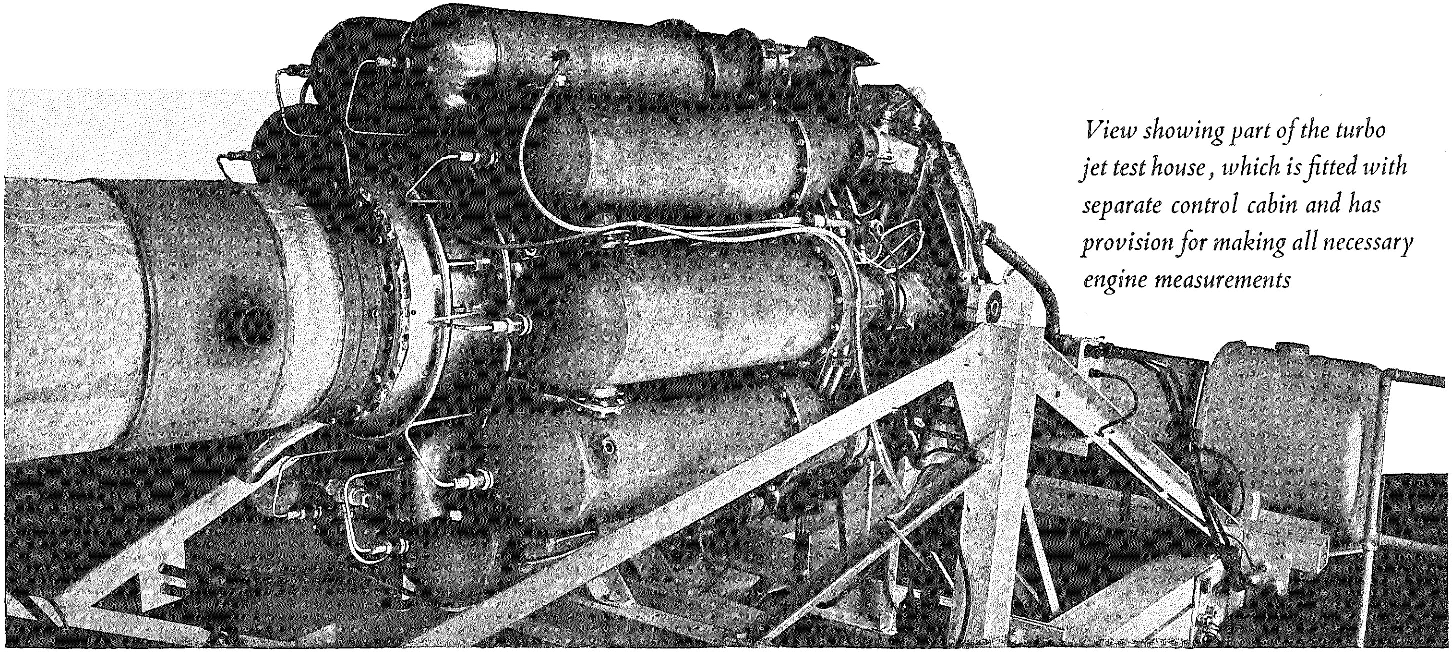
As the Department's facilities develop, the participation in a certain amount of research work for outside interests is considered desirable, possessing, as it does, an educational value for staff and students alike. Such research is, in fact, already being performed to a limited extent and will steadily become of greater importance.

The thesis work that the students carry out in their second year is arranged to be part of a broad research programme, so that as time goes on a useful field of research is covered.

The Department has formed a collection of typical examples of both engine components and complete power plants, ranging from piston engines to various types of rocket motor. This collection will be kept up to date, and is in general



Part of the Propulsion Laboratory, where rig tests are carried out on engine components and sub-assemblies



View showing part of the turbo jet test house, which is fitted with separate control cabin and has provision for making all necessary engine measurements

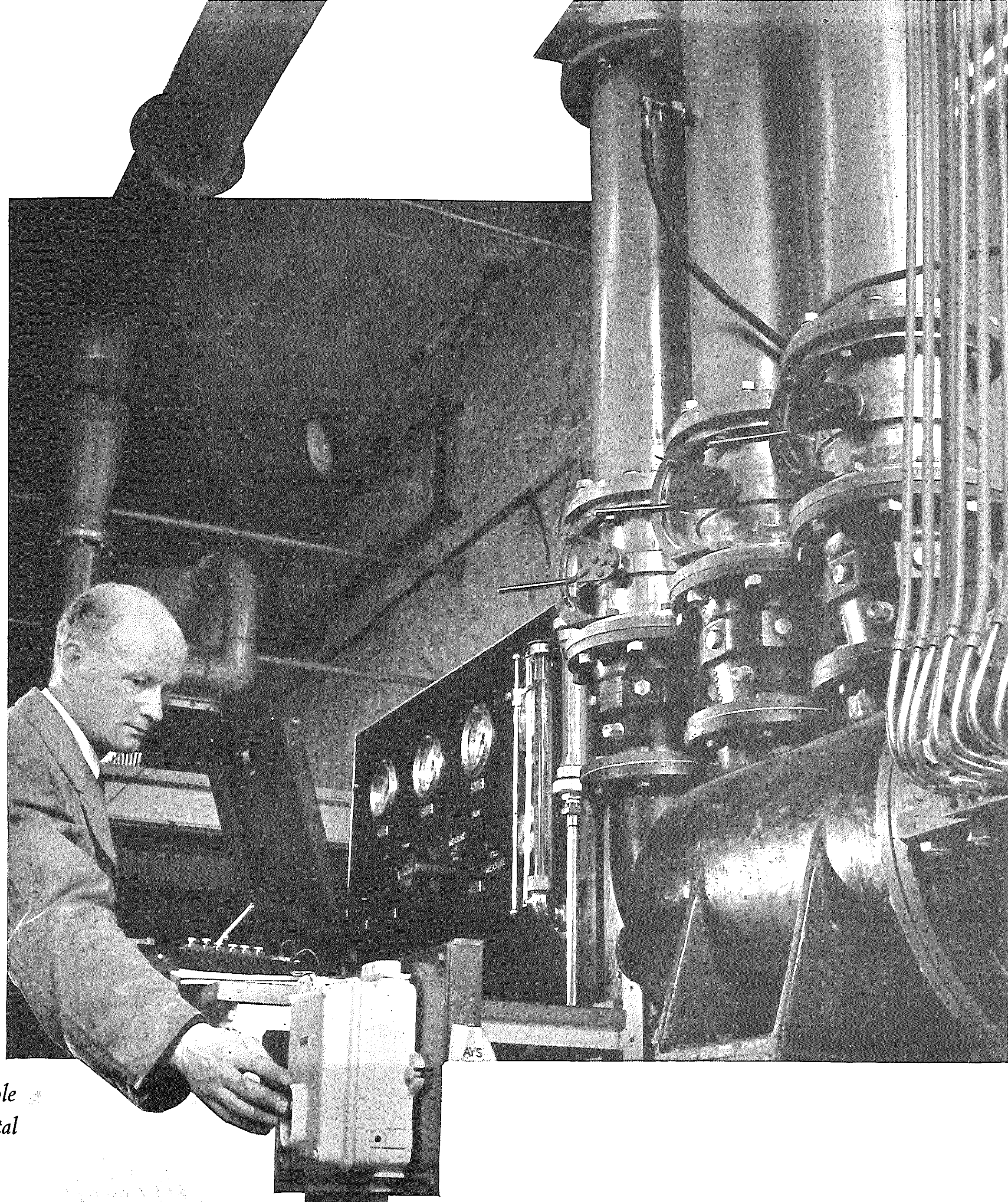
use in connection with the more practical side of the lecture course.

The test house area is situated a short distance away from the main College buildings, with a view to reducing the disturbance due to the noise associated with the operation of aero engines. It comprises a number of individual cubicles, each with about 600 square feet of floor area, in which the demonstration and research units are installed.

On the piston engine side there are a number of single cylinder units, a medium power multi-cylinder air-cooled engine driving a Heenan and Froude eddy current dynamometer, and a propeller test stand on which liquid- or air-

cooled engines can be run. There is also a Hercules XVI engine installed in a specially instrumented Halifax aircraft, suitable for ground testing and complete with torquemeter and associated equipment. This was obtained, in the first case, to provide quickly a simple form of test bed, but it has been found to have other advantages justifying its retention.

The gas turbine aspect is covered by a full-scale turbo-jet test house, with separate control cabin, and as soon as possible a turbo-propeller engine will be installed in a hangar test stand. In order to carry out investigations into the air flow and combustion in aero engines, an adequate air supply is necessary. There is available at present some $3\frac{1}{2}$ lb. per sec. at a relatively low pressure, and this will be supplemented in the near future by a considerably larger supply at two to three atmospheres pressure. The



One of the full scale gas turbine combustion chamber rigs. Other apparatus is available for carrying out more fundamental research in combustion

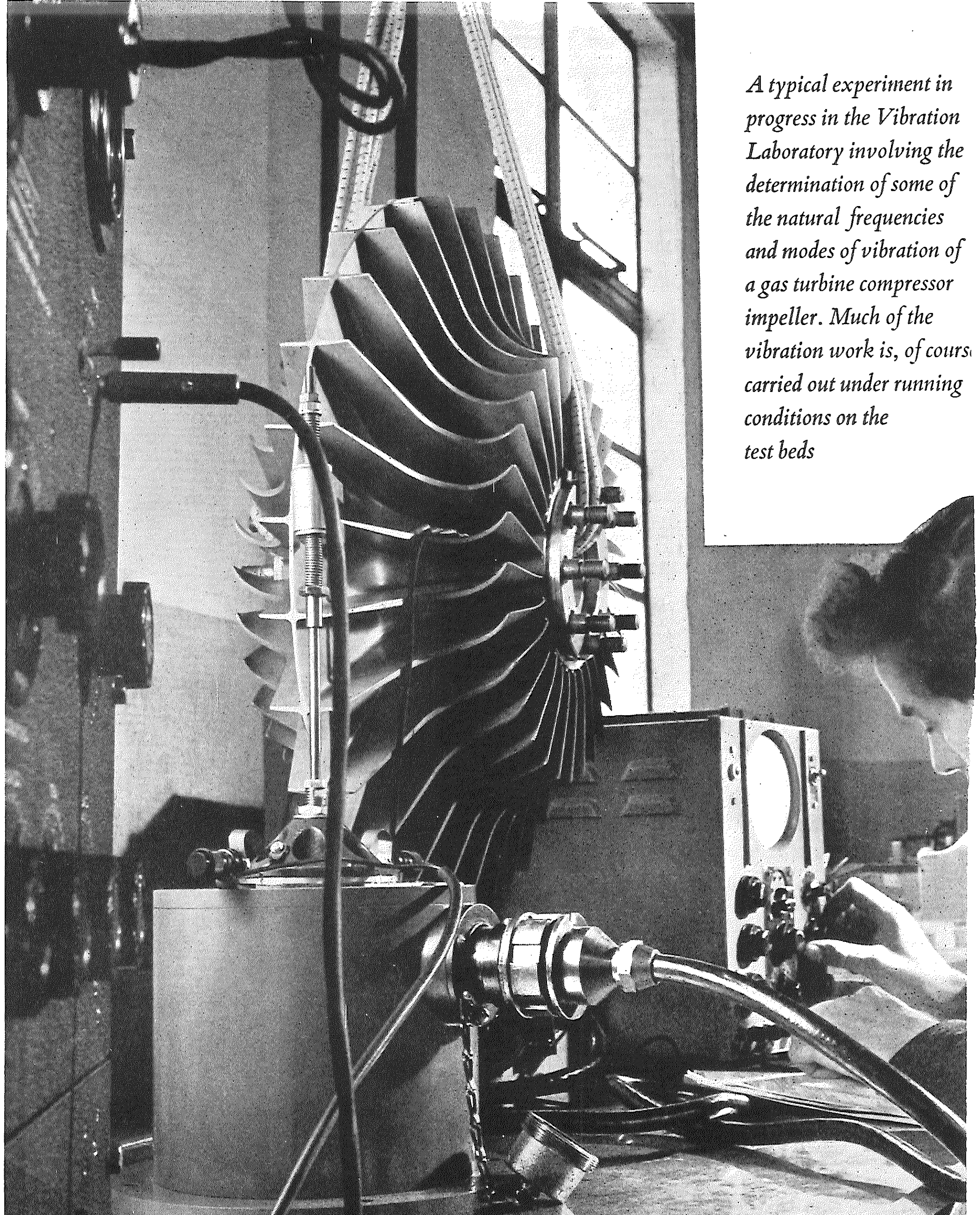
equipment for this is available but is not yet fully installed.

To investigate the combustion side of ram-jets and gas turbines several small fundamental rigs are being installed to give basic instruction on this subject. There is also a full-scale gas turbine combustion chamber rig.

As regards rocket motors, a small unit in a temporary test house is available for research work and a larger permanent test house will be erected in the near future.

Apart from the test house area, there are several other laboratories. One of these is set aside for rig tests on engine accessories and another for static and dynamic stress measurements on engine components. The apparatus here includes suitable strain gauge apparatus and a photo-elastic unit.

There is also a laboratory for vibra-



A typical experiment in progress in the Vibration Laboratory involving the determination of some of the natural frequencies and modes of vibration of a gas turbine compressor impeller. Much of the vibration work is, of course carried out under running conditions on the test beds

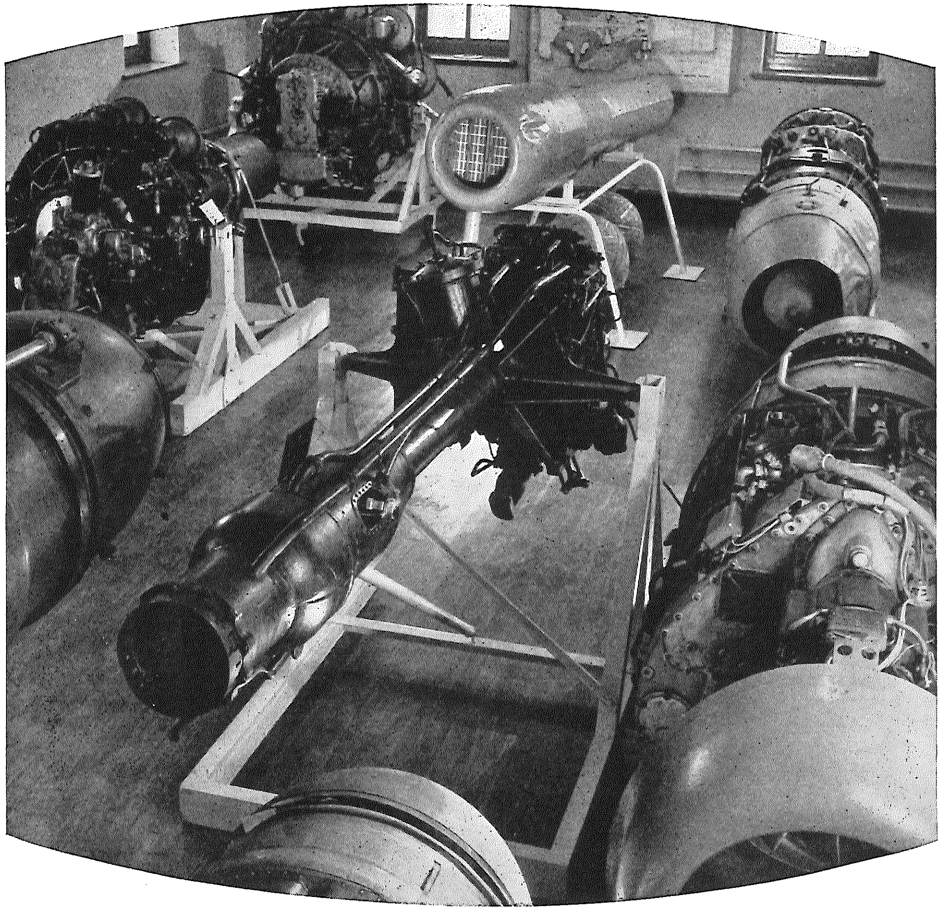
tion investigations on engine components, the vibration characteristics of complete power units being studied on the test beds.

A water channel is available for studying the analogy between shock waves in a gas and surface waves on water. In this connection cascade tunnels will be installed as soon as an adequate air flow is available.

In the Fuels Laboratory, investigations are made into the analysis and properties of various aircraft fuels.

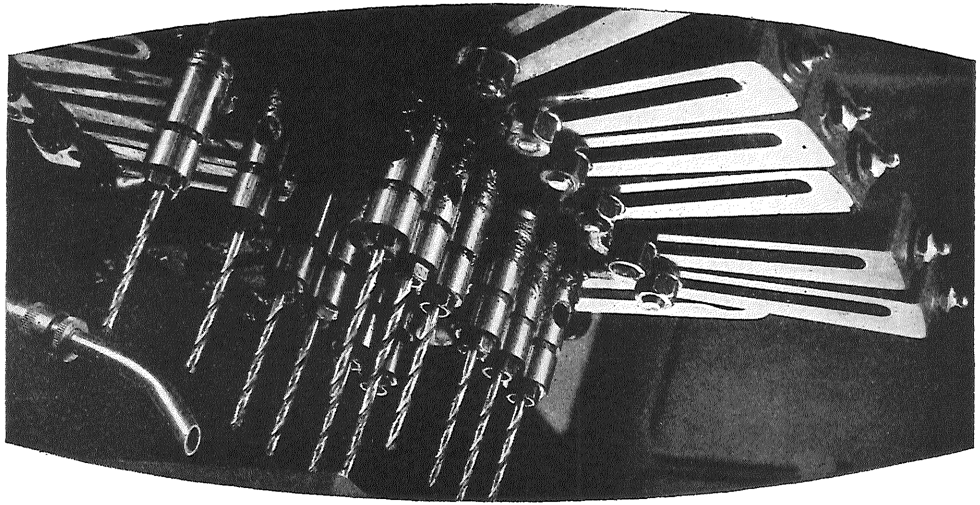
Equipment is also being installed to carry out performance tests on various types of heat exchanger.

The Department has two well-equipped drawing offices which are laid out, as far as possible, on the lines of their industrial counterparts, and have facilities for tutorial discussion in the course of design instruction.



Part of the Engine Demonstration Laboratory.
A general view of the gas turbine and rocket section

THE DEPARTMENT OF AIRCRAFT



ECONOMICS AND PRODUCTION

Syllabus * FIRST YEAR

GENERAL BACKGROUND SUBJECTS

Structure of Manufacturing Enterprises: TYPES OF MANUFACTURING ENTERPRISES. THEIR FINANCE AND OPERATIONS WITH PARTICULAR REFERENCE TO THE AIRCRAFT INDUSTRY.

Economics and Industrial History: EVOLUTION OF MODERN INDUSTRIAL MANAGEMENT. BASIC ECONOMICS OF BUSINESS.

Industrial Law: LEGAL CONSIDERATIONS AFFECTING ENGINEERS AND MANAGERS.

Economics of Aircraft Operation: FACTORS INFLUENCING OPERATIONAL ECONOMY. THE SELECTION OF AIRCRAFT.

BASIC TECHNIQUES

Industrial Accounts: PRINCIPLES OF FINANCIAL AND COST ACCOUNTANCY.

Industrial Statistics: STATISTICS USED FOR SOLUTION OF INDUSTRIAL AND ADMINISTRATIVE PROBLEMS.

Inspection of Measurement: PRACTICAL METROLOGY AND FINE MEASUREMENT AND CONTROL OF QUALITY AND LIMITS.

Time Study: ALL ASPECTS OF WORK MEASUREMENT: INCENTIVES.

Motion Study: ALL ASPECTS OF MOTION ANALYSIS AND WORK SIMPLIFICATION.

Personnel Management: INDUSTRIAL PSYCHOLOGY AND PRINCIPLES OF MANAGEMENT OF LABOUR.

PRODUCTION ENGINEERING SUBJECTS

Jig, Tool and Gauge Design: GENERAL PRINCIPLES OF DESIGN OF JIGS AND TOOLS AND ECONOMICS OF TOOLING.

Production Design: METHODS OF DESIGN FOR DIFFERENT SCALES OF PRODUCTION AND ECONOMIC ASPECTS OF THESE METHODS.

Aircraft and Engine Production Processes: AN ANALYSIS OF PRODUCTION TECHNIQUES AND USE OF MACHINE TOOLS, PLANT AND EQUIPMENT. CUTTING TOOL THEORY AND RESEARCH.

Aircraft and Engine Maintenance: COST OF MAINTENANCE AND INFLUENCE OF MAINTENANCE ON DESIGN.

MANAGEMENT SUBJECTS

Organisation: PRINCIPLES OF VARIOUS FORMS OF ORGANISATION AND HUMAN FACTORS INVOLVED.

Administration and Management: PRINCIPLES OF ADMINISTRATION AND MANAGEMENT. TECHNIQUES OF EXECUTIVE CONTROL.

Engineering Economic Analysis: ANALYSIS OF COST AND VALUE. TECHNIQUES OF DETERMINING OVERALL ECONOMY OF ENGINEERING PROJECTS.

SECOND YEAR

The Second Year consists of an expansion and enlargement of the majority of the First Year subjects and the more detailed consideration of advanced aspects and techniques. In addition, the following subjects are given:

Planning, Estimating and Cost Control

PREPARATION OF PRODUCTION PLANS, SCHEDULES, SHOP LOADING. ESTIMATION OF TIME CYCLES OF MAN HOURS. PROGRESS SYSTEMS. COST BUDGETS AND COST CONTROL.

Production Control

CONTROL OF PRODUCTION AT THE HIGH LEVELS AND INTEGRATION OF ALL PRODUCTION DEPARTMENTS IN THE MANUFACTURING PLAN.

Aircraft Economics

ADVANCED ASPECTS OF THE ECONOMICS OF AIRCRAFT OPERATION AND SPECIFICATION OF OPERATING REQUIREMENTS.

Market Research and Assessment

ANALYSIS OF DATA FOR FORECASTING TRENDS AND INTERPRETATION OF BUSINESS INFORMATION AND STATISTICS.

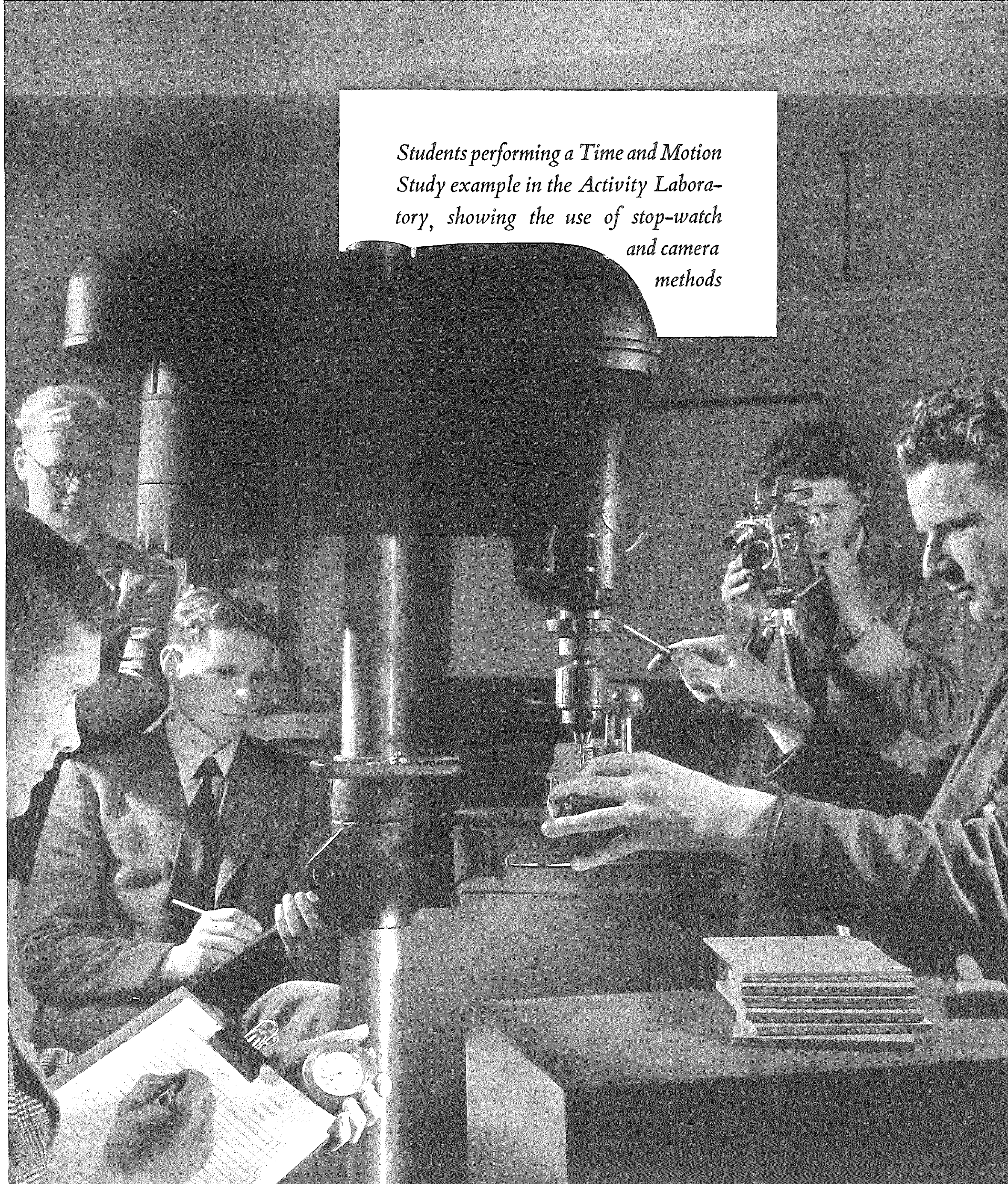
ircraft production problems differ from those which have been solved in other manufacturing industries. During the war it became clear that special conditions prevail in an industry which is complex, which demands high standards of workmanship and is also required to undertake great expansion in time of war. The most evident need is for a sufficient number of trained engineers to form a nucleus to deal with the problems of expansion and still to produce the smaller quantities required under peace-time conditions in an economical manner. This need is not adequately met by reliance on the diversion, in an emergency, of men trained in other industries, to the manufacture of aircraft.

Both production engineering and scientific management have emerged as recognisable professions during the early part of this century but, until recently, no advanced training has existed in the Universities here, and traditional methods

left the acquisition of this knowledge largely to chance. The Fedden Report, recognising this situation, recommended that a production department should be set up at the College. The lack of any precedent in Britain made it advisable to defer the institution of this course until 1948 after a careful scrutiny of the whole subject had been made.

In miniature the essential features of the whole aircraft industry are represented at Cranfield and this is advantageous to the department. Many aspects of management are represented within the College and this is also of great benefit in keeping theoretical training in close contact with active practice. The general facilities of the College can, therefore, be regarded as supplementing the laboratories of this department.

Primary importance has been attached to the Administrative, Management and Design aspects of Production Engineering. It is those branches which



Students performing a Time and Motion Study example in the Activity Laboratory, showing the use of stop-watch and camera methods

cannot be taught to immature engineers, or for which no facilities exist in normal training institutions, which are emphasised in the teaching of the department. These are covered in a comprehensive manner by the following group of subjects:

Administration, Organisation and Management;

Methods of Budgetary and Production Control (Punched Cards Systems, Business Systems, Accounts etc.);

Measurement and Metrology and their application to Jigs and Tools;

The Economics of Machine Tools and Production Plant; Time and Motion Study in all its aspects.

Production technology training is provided in the well-equipped Industrial Laboratory, supplemented by other facilities in the College.

Vacation training in the industry and visits to selected firms constitute further means for gaining practical experience, and in the preparation of the thesis most students make useful industrial contacts.

Knowledge of the appropriate production technology is essential for a production engineer in industry, but this knowledge can usually be acquired rapidly and satisfactorily in the actual field of manufacture if the right foundations exist. The usual process is by apprenticeship in the early stages of training or by post-graduate apprenticeship in a specific field of activity for trained engineers. What the College course provides is a sound knowledge of the basic principles applicable to all techniques.

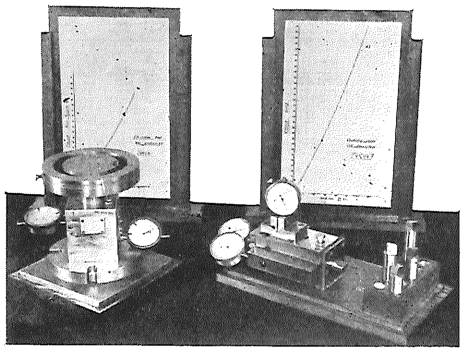
Two types of first-year course are available; a provision necessary to cater for:

(a) Students requiring a general background of industrial knowledge (Course 'A');

(b) The Department's specialist students and students desiring more substantial knowledge (Course 'B').

Course 'A' covers most of the field in a non-detailed way, some subjects being introduced in a general manner to emphasise their relationship in the general scheme. This course provides a useful background for all engineers and is sufficient to give the student an intelligent understanding of methods of approach and the use of textbooks and papers which deal with the subjects.

Course 'B' is an amplification of the subjects taught in Course 'A', adequate

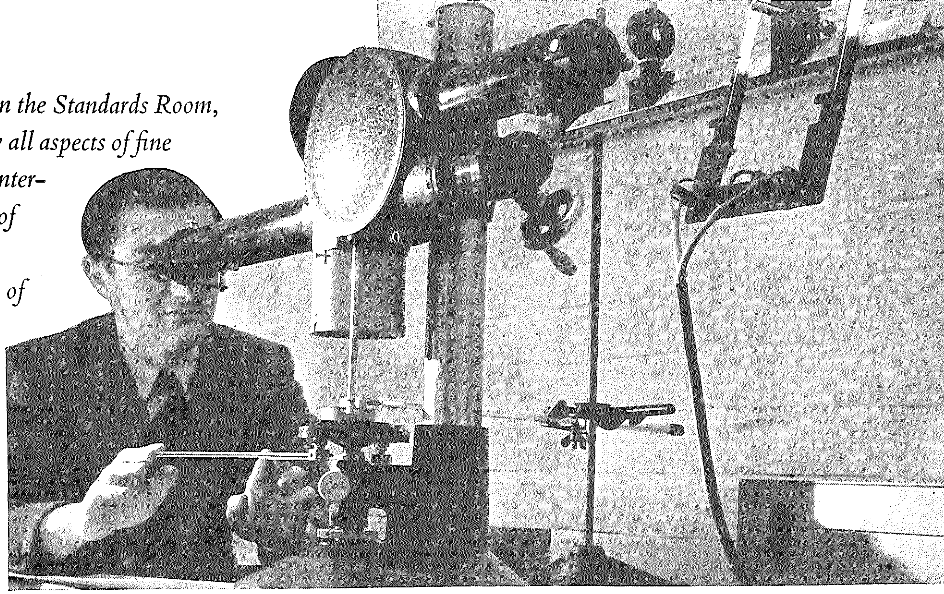


Drill and Lathe Cutting Tool Dynamometers. These measure accurately the cutting forces when machine tools are operating

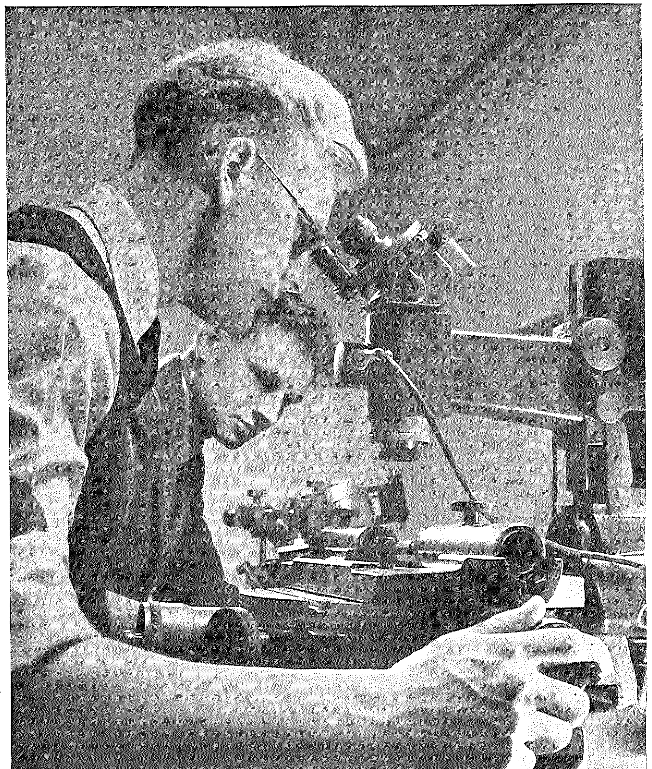
for the Department's specialist students to proceed to post-graduate work in their second year and also to enable students who are specialising in other subjects to handle normal production problems, and particularly to avoid serious errors in this field.

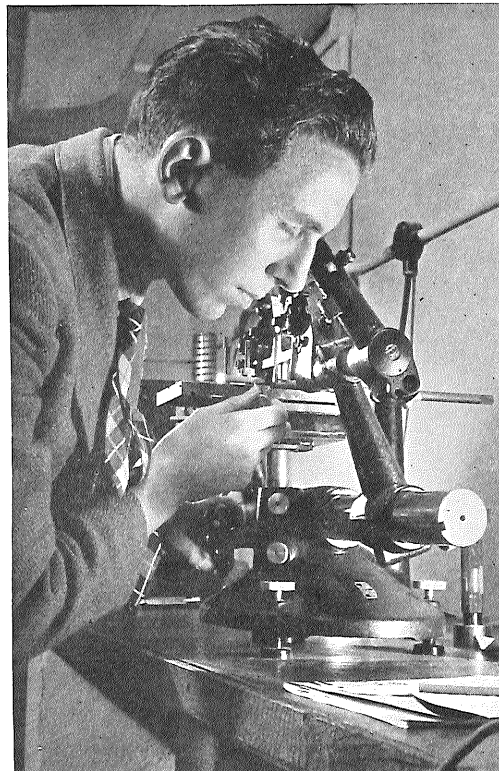
In the second year all the additional subjects in the syllabus are brought in at the appropriate stages, and first-year lectures are expanded in some detail.

The linking-up of the various subjects is accomplished by a series of 'Case Studies', in which the students work through in considerable detail a complete project covering the setting up of a factory and the solution of production problems arising in an aircraft manufacturing programme. This is done in as realistic a manner as possible. As far as time permits, every activity in such a process is represented by the working out of a proposal; for example, the design of a factory layout or a control system



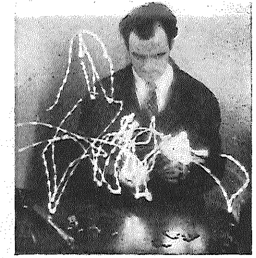
A group of pictures in the Standards Room, where students study all aspects of fine measurement. The interferometer at the top of the group is used to determine the length of slip gauges against a light wave standard and to a few millionths of an inch

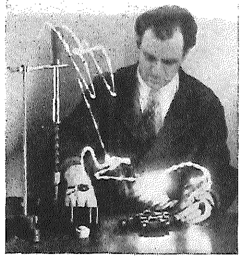




AIRCRAFT ECONOMICS & PRODUCTION

procedure. Regular meetings of various representative kinds are held and reports and drawings are made on a wide range of matters, ranging from contracts to jig and tool design.

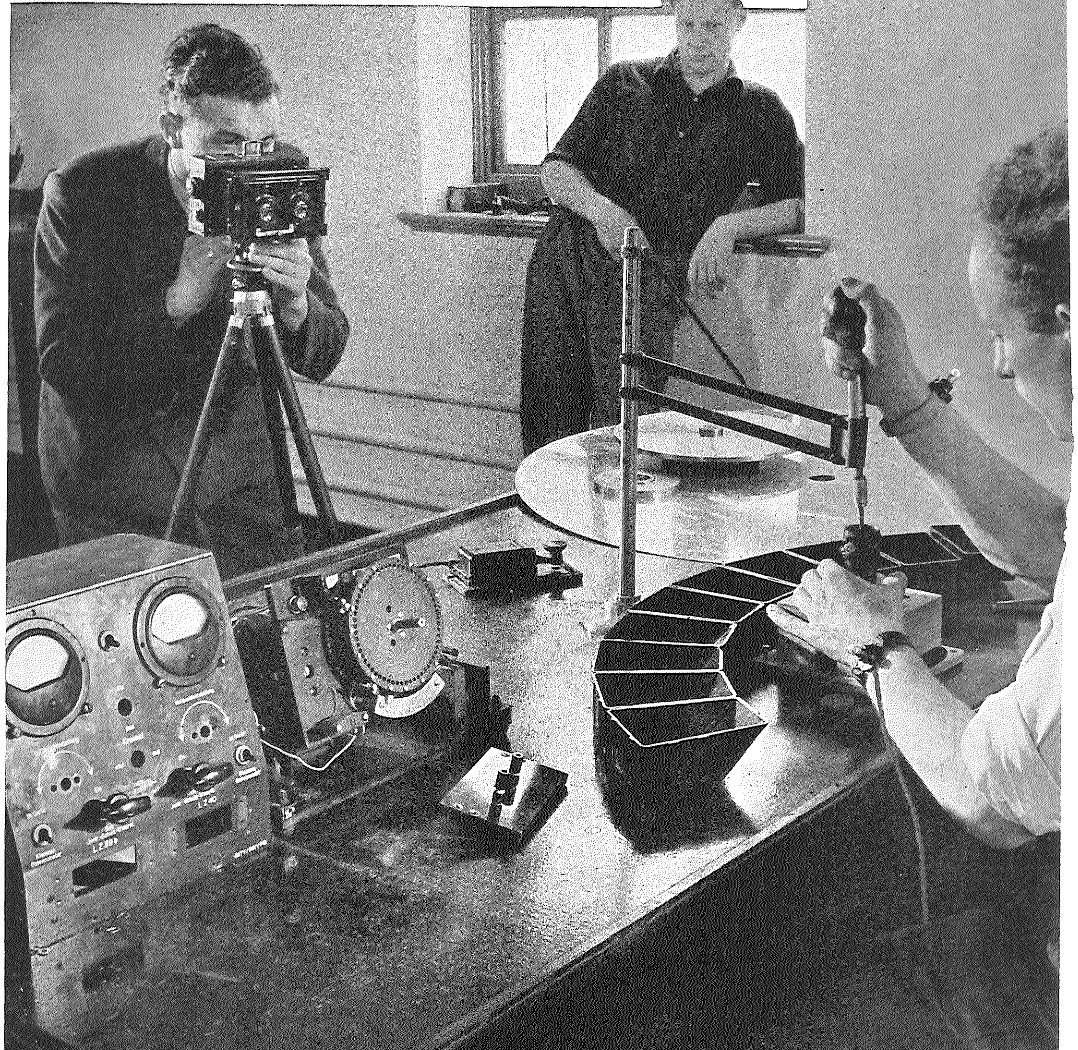




(RIGHT) *Photographs showing the hand movements before and after motion analysis, taken with the cyclochronograph*

Due to the general facilities existing in other teaching departments and in the common services of the College, it has been possible to concentrate development on laboratories dealing with specialist and business subjects, and the department has the following laboratories

INDUSTRIAL MACHINE TOOL LABORATORY, equipped with a wide variety of production machine tools which cover in principle all the main machining processes. Some of these machine tools are of advanced design. Here students deal with the economics of machine tools and cutting tool research.



A stereo-cyclochronograph study of an Assembly Job, showing the flash generator and wrist lights

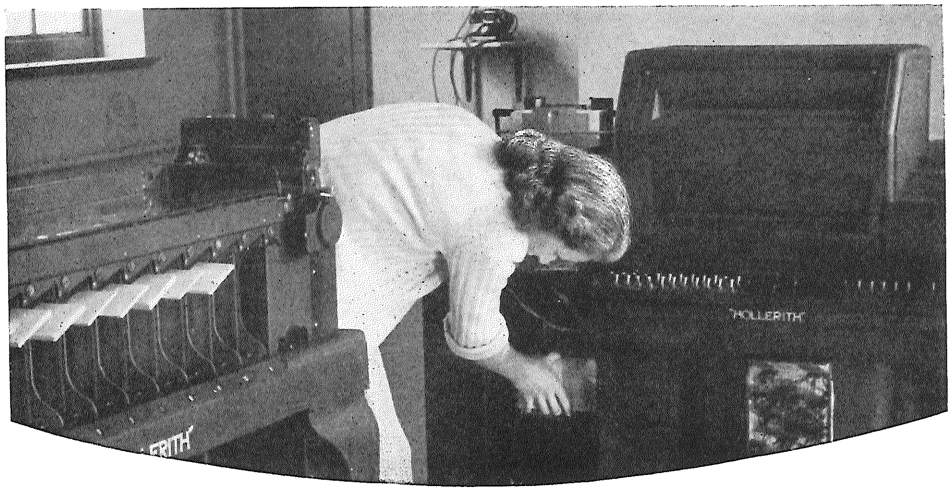
STANDARDS ROOM AND METROLOGY LABORATORY. This is one of the most fully equipped in the country and is situated in an air-conditioned building with accurate temperature control. Almost every type of measurement relating to linear and angular dimensions can be made to the highest degree of accuracy. Length of standards can be established by interferometry. British, German, American, Swiss and Swedish instruments permit the use of a great variety of methods.

JIG & TOOL LABORATORY, for checking and manufacturing sample jigs and tools and for their measurement and inspection. It is associated with the Standards Room and Industrial Laboratory, on which it can call for help in both measurement and tool manufacture. Facilities are also available for surveying techniques in setting out large jigs and tools.

ACTIVITY LABORATORY, equipped with the latest instruments for conducting method, motion and micro-motion studies in addition to the stop-watch procedures, all forms of work measurement and some physiology and psychology equipment where appropriate to production.

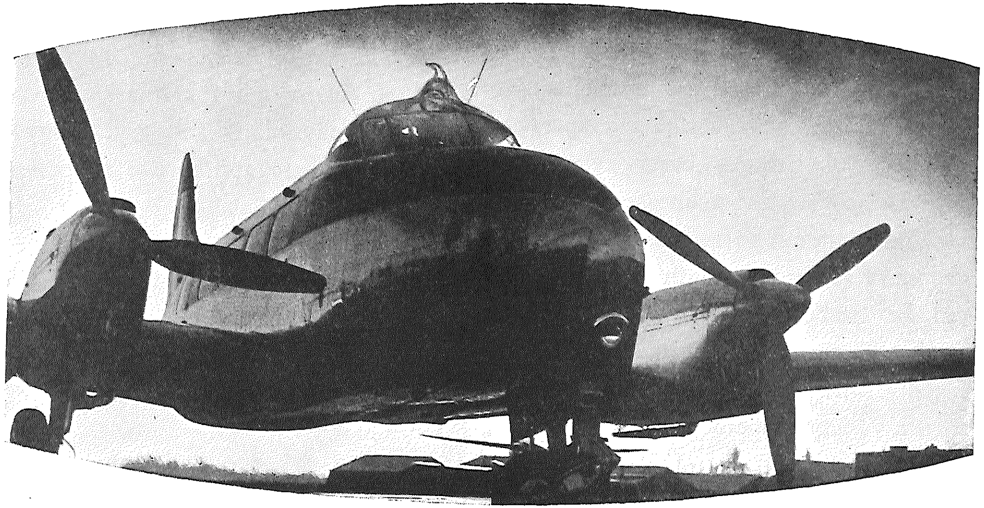
BUSINESS SYSTEMS LABORATORY This is equipped with samples of most of the important varieties of card index and control chart systems, has various forms of office machinery, including the Hollerith punched card equipment, and covers the whole field of production and financial control.

INDUSTRIAL PROCESSES LABORATORY, which is attached to the Materials and Metallurgy Section, and is described later in this book.



The Business Systems Laboratory showing some of the equipment for production and financial control

THE DEPARTMENT OF FLIGHT



Syllabus * FIRST YEAR

GENERAL SCOPE OF THE COURSE.
METHOD OF REPORTING TESTS.
BASIC FLIGHT TEST INSTRUMENTS AND THEIR CALIBRATION.
RULES OF THE AIR. WEIGHING AND CENTRE OF GRAVITY DETERMINATION.
POSITION ERROR MEASUREMENT (*Aneroid method, trailing static, speed course, radar etc.*). AIR THERMOMETER CALIBRATION. INVESTIGATION OF STALLING BEHAVIOUR. PERFORMANCE TESTING (*Partial and Ceiling Climbs. Speed Power Relationship. Variation of level speed with height. Fuel consumption and range tests. Take-off investigations*).
MEASUREMENT OF DRAG BY PITOT TRAVERSE.
LONGITUDINAL STABILITY TESTING (*Determination of stick-fixed and stick-free static stability margins*).
COMPASS SWINGING AND ADJUSTMENT.
MODERN RADIO AND RADAR AIDS (*Lectures and demonstrations given in co-operation with the Radio and Electrical Section*).

SECOND YEAR

In the second year, students select experiments having a direct bearing on the subject in which they are specialising. A typical syllabus would include the following:

A MORE DETAILED TREATMENT OF THE MEASUREMENT OF STATIC LONGITUDINAL STABILITY MARGINS (*Effect of slipstream. Aeroelastic distortion, Compressibility etc.*)
MANOEUVREABILITY (*Stick-force/g*).
MEASUREMENT OF AILERON POWER AND HINGE MOMENTS AT VARIOUS SPEEDS (*Deduction of aileron reversal speed*).
INVESTIGATION OF THE BEHAVIOUR OF AN AIRCRAFT IN ASYMMETRIC FLIGHT AND UNDER ASYMMETRIC POWER (*Determination of safety speed*).
PERFORMANCE REDUCTION FOR JET-PROPELLED AIRCRAFT.
GENERAL HANDLING TESTS.
METHOD OF OBSERVING TRANSITION IN FLIGHT.
INSTRUMENTATION FOR MORE ADVANCED FLIGHT TESTING.
MEASUREMENT OF LOADS AND STRESSES BY STRAIN GAUGES.
VIBRATION MEASUREMENT. EFFECT ON FUEL CONSUMPTION OF VARIATION OF MIXTURE STRENGTH AND IGNITION SETTING AT VARIOUS R.P.M., BOOST PRESSURES, SPEEDS AND HEIGHTS.
MEASUREMENT OF THE AIR MASS FLOW THROUGH THE ENGINE.
ANALYSIS OF EXHAUST GASES FROM INDIVIDUAL CYLINDERS.

FLIGHT

THE AIRCRAFT, airfield, hangars and maintenance shops of the Department of Flight form an appropriate background to the life and work of students at Cranfield. Here can be seen the complete reality evolved from theories they have examined in the Department of Aerodynamics, problems similar to those they have worked on in the Departments of Aircraft Design and Propulsion, and the production methods studied in the Department of Aircraft Economics and Production.

As well as being able to provide the students with actual flying experience to demonstrate the theories taught in the other departments, the department has complete facilities for flight testing and full scale research. It can thus at all times provide instruction in the latest methods of testing aircraft and aircraft equipment in flight. The department is used as an instrument to illustrate and supplement other aspects of the students' work. To this end every endeavour is made to arrange the flying programme so that it keeps in step with the students' current theoretical work.

The College fleet of aircraft consists, at present, of a Dove, three Ansons, and three Tiger Moths. The Dove and Ansons are used to demonstrate modern flight testing technique. In the first-year syllabus emphasis is placed on the performance testing of piston-engined aircraft and on elementary handling characteristics. Towards the end of the year the elementary longitudinal stability characteristics of an aircraft are determined. In the second year the specialists in various departments perform flight investigations directly concerning their particular subjects; for example, students specialising in aerodynamics investigate more completely the stability, control and handling characteristics of the aircraft. The Propulsion specialists collect information on the effect of variation of mixture strength and ignition setting on fuel consumption over a range of engine speed, forward speed and altitude, on the air mass flow through the engine for various conditions of flight speed, engine speed, boost and height; and carry out analysis of exhaust gases.

Important techniques such as performance testing of jet-propelled aircraft and the testing of controls at high speeds are taught in the classroom and wherever possible illustrated by results collected from external sources.

Second-year students are encouraged to undertake simple pieces of full scale research having a direct bearing on their specialisation, these investigations being supervised jointly by the student's Department and the Department of Flight.

A secondary function of the Department of Flight is to arrange airborne demonstrations of the latest radar aids to navigation to supplement the lectures given in the Electrical Section. While

mental work in the laboratories. Throughout the whole course special attention is given to the integration of theory, practice and experiment.

On leaving the department students may find employment in structural or mechanical design work, in research or project work or in a stress office, and the scope of the course is arranged to provide each student with the most advanced and up-to-date knowledge in any of these branches.

Inspection of the abridged syllabus will show the nature of the lecture courses available for the student, but these courses present only a section of the teaching. The other sections, comprising the drawing office and the laboratories, are considered to play an equal part with the lectures, and to develop by physical concepts the more abstract matters dealt with in the lectures.

In the second year, emphasis is placed on the capacity of the student to think about and handle design problems

First Year Students in the Drawing Office. The course emphasises drawing office work throughout

for himself, and to this end each student is asked to carry out a piece of thesis work and design a section of an aeroplane. The thesis may be either theoretical or practical, and as far as possible is matched to the interests of the student; subjects so far range from theoretical work on sandwich construction to structural testing of stringer skin panels and a study of generator brush wear at high altitude. As will be seen later, the facilities of the department provide for the tackling of a very wide range of subjects. The design consists of the layout, structural or mechanical design, or both, and stressing of a unit of an aeroplane such as a wing or undercarriage. Each student has a section of a complete aircraft to handle and, by working together, students get valuable experience of the design procedure in aircraft firms.

The lecture courses are set out, not only to satisfy the needs of the specialist, but also to enable students specialising in other departments to get some insight into aircraft design procedure. The lectures are arranged to follow certain lines of approach to the various problems. Overall design problems are met by lectures in detail design and installation in the first year, followed by lectures in the second year on project design, general structural design and more advanced installation problems. This course is linked with drawing office work in the first year on detail components, and laboratory work on installations; and in the second year with the design of aircraft components mentioned earlier.

The structural and stressing aspect is developed in the first year by lectures on theory of structures and elementary stressing, and in the second year by more advanced structures, more complex stress problems and, for the research student, advanced theory of elasticity. This is linked with laboratory work on structure testing and the stressing of the designs previously mentioned.

Instruments and instrumentation now play such a large part in the design of an aeroplane that lectures are given in the first year to provide an insight into instrument design from the users' angle, and also to deal with such items as auto-pilots, bomb sights and others even more complex. This course is linked with laboratory work to give students experience in handling instruments.

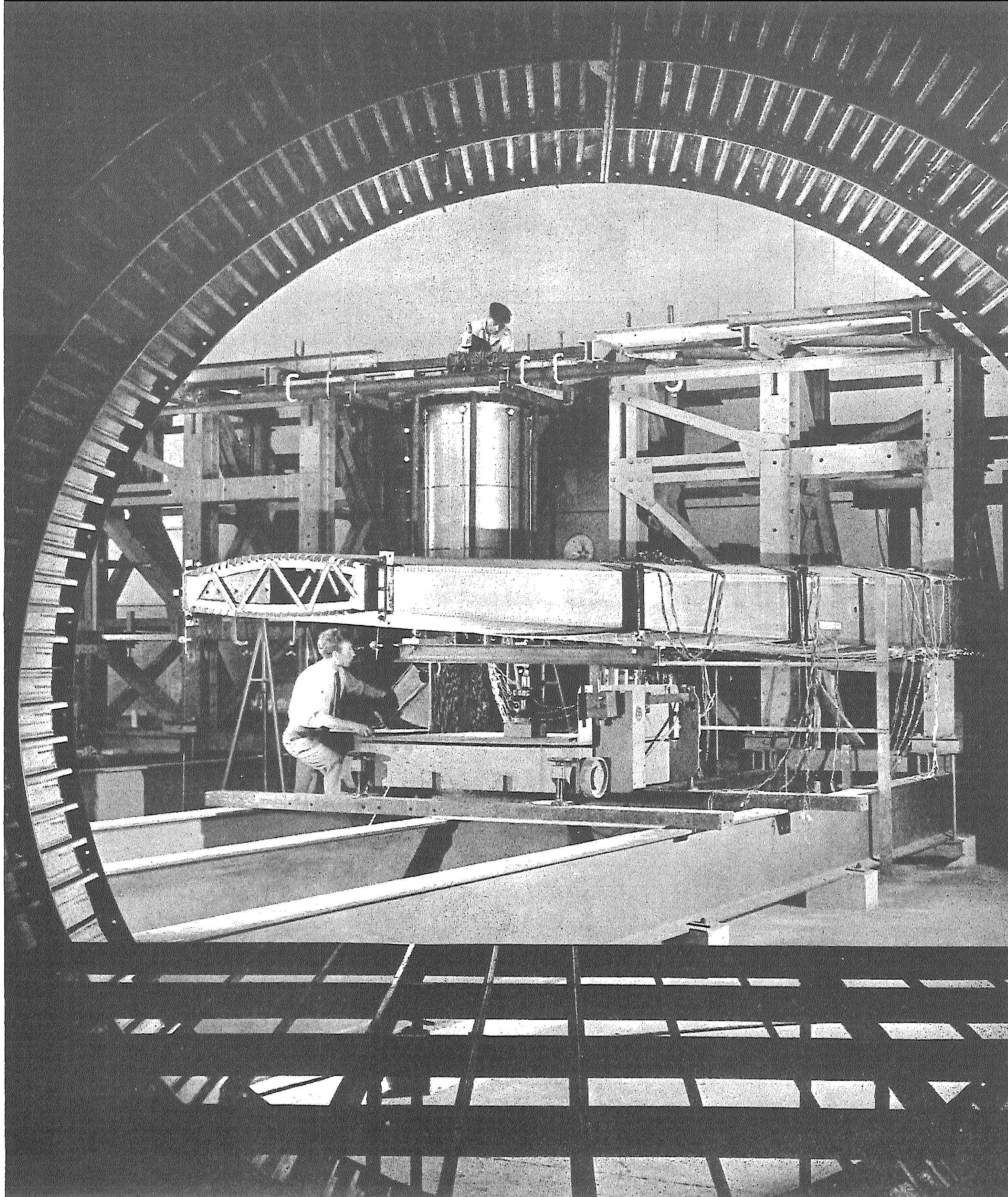
The whole course has been laid out so that at all times theory and practice are linked together to give the student a full picture of what takes place in a design office. Drawing office work, test work in the laboratories, stressing and exercises all have their part in this and, in addition, close collaboration is maintained with other departments, especially that dealing with Economics and Production, to link up design with manufacturing processes and problems. Visiting experts from the aircraft firms, R.A.E. and the Services are asked to come and give their viewpoint to the students. Visits to aircraft and related factories are also arranged to

keep students in touch with the latest trends of development.

The staff of the department have been carefully selected to cover a wide range of theoretical and practical experience, and have all had considerable experience either with aircraft firms or in the Services. They thus bring to the work a wide knowledge of design practice without which the course detailed above could neither be useful nor satisfactory.

Research on structures and on other problems in the broad field of design is encouraged and the extensive range of thesis work is, as far as possible, organised to increase structural knowledge and to give the designer working rules for handling his everyday structural and stressing problems.

The course detailed above would have no chance of success without first-class laboratory facilities, capable of meeting ever-changing testing methods and problems set by new types of aircraft.



Structures Test Rigs.
Research investigation
in progress on load
distribution in a metal wing

In fact, the facilities, as can be seen by the photographs and the description which follows, are without equal in any teaching establishment in the world, and they are so laid out as to remain flexible and meet any development likely to arise in the future.

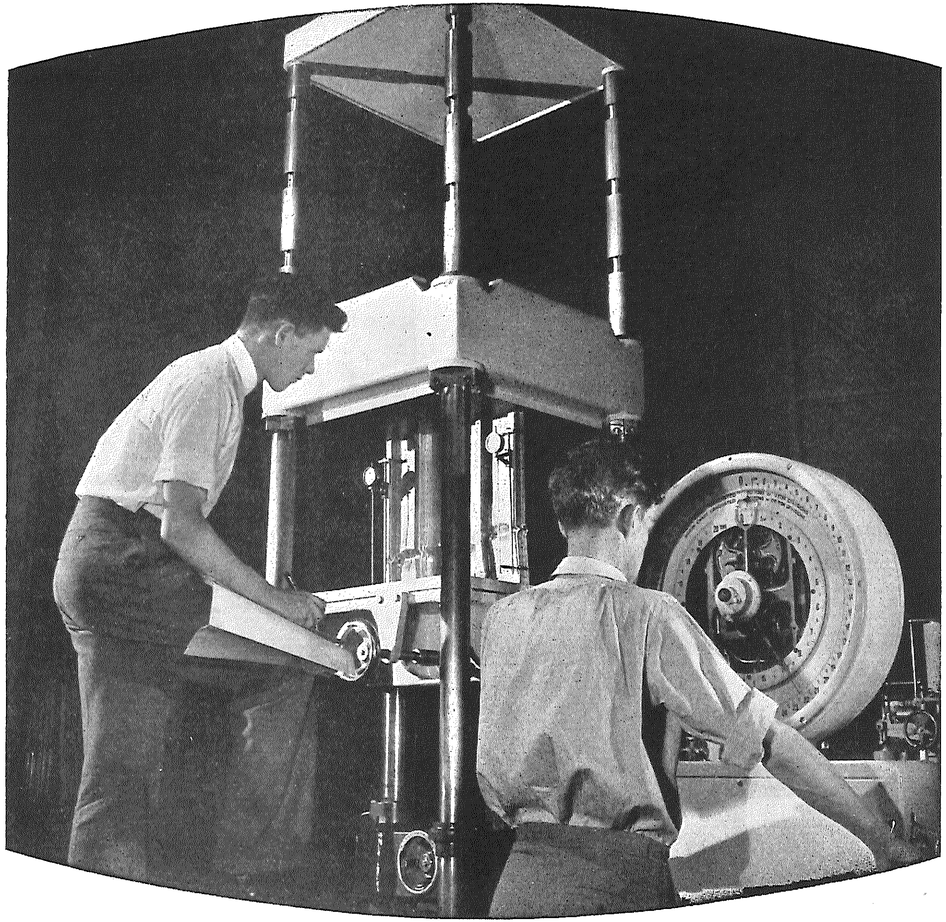
THE STRUCTURES LABORATORY has a comprehensive range of facilities including:

(1) A very complete range of testing machines from 1 ton to 150 tons capacity, some modified and some specially designed for panel testing and other problems of testing peculiar to aircraft. With these machines tests can be made on an extremely wide range of representative aircraft parts.

(2) Fatigue testing machines capable of taking built-up parts; the largest of these can test parts up to 4 ft. long with a load range of 15 tons ± 10 tons.

(3) Hardness testing machines of various types including Vickers, Brinell and Rockwell.

(4) Frames for testing aircraft structures such as fuselages and for showing the principles of still larger tests.



A panel test in progress in a testing machine specially modified by the College for this work

the object is not to train students as radio operators, this demonstration serves to give them a good knowledge of the uses and limitations of the various aids.

The students are taught the theory underlying the various flight testing techniques and reduction of results. They are then divided into groups of four to six and take observations in flight under supervision. Having completed their investigations, they are required to submit a formal report to the Department. Although the emphasis is on the training of technicians, it is considered desirable that students should be fully conversant with the piloting technique required for the various tests.

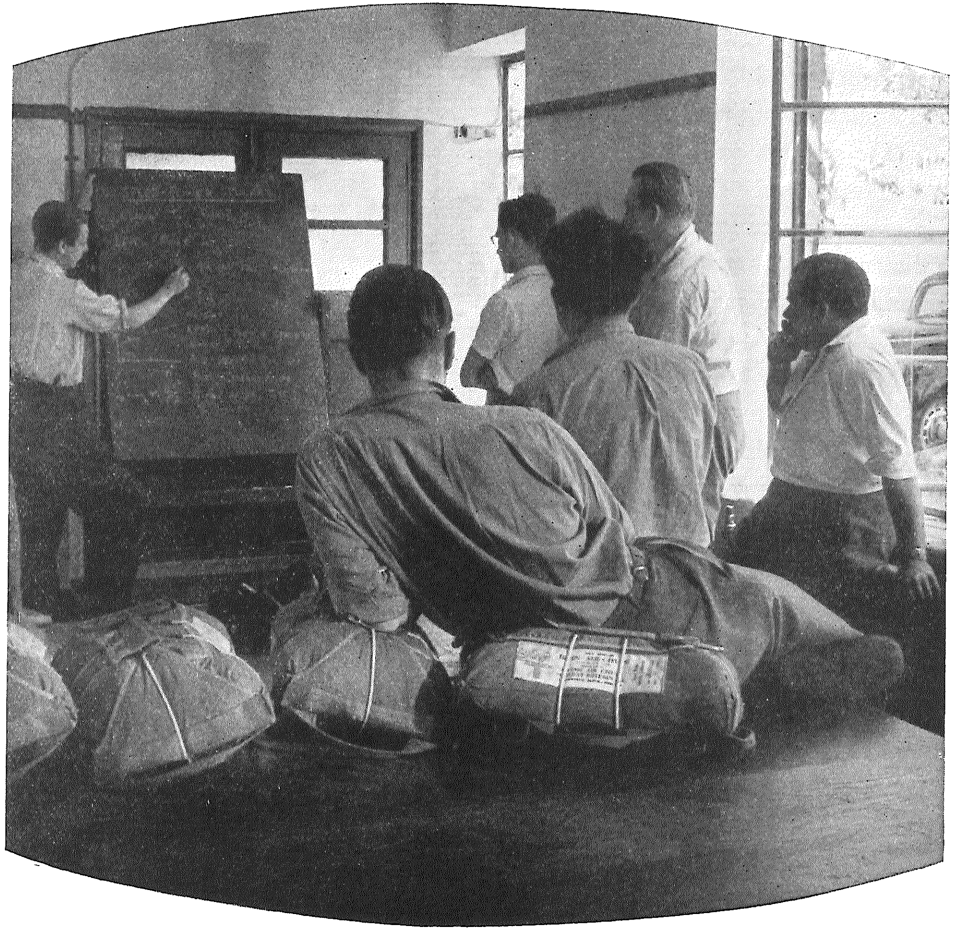
There is also an ab initio flying training scheme by which students can be taught to fly to solo standard at reduced charges. Instruction is given on Tiger Moth aircraft by a full-time flying

Air traffic control, showing the hangars and aircraft of the Department in the background

instructor, and most of the students avail themselves of this opportunity.

The Department occupies two hangars, which, in addition to housing the aircraft, contain the teaching equipment and demonstration rooms. Among these are a radio demonstration room where all modern types of radio and radar apparatus can be inspected, a projection room where 35 mm. and 16 mm. projectors are installed to enable students to analyse photographic records of their tests, and the briefing room where all the relevant data for the reduction of results is kept. There is also a fully equipped instrument section for the inspection, overhaul and construction of instruments.

The Department has full facilities for aircraft maintenance, including metal, woodwork, electrical and radio workshops, a section for the repair and over-



Students being briefed prior to flight on the measurement of speed-power relationship on Anson aircraft

haul of tyres, and hydraulic and plug bays. The inspection department is fully approved by both A.R.B. and A.I.D., and has under its supervision the bonded and quarantine stores. Students are encouraged to take an interest in the various problems associated with the maintenance and operation of aircraft.

FLIGHT TEST AIRCRAFT

The Dove and Anson aircraft are all completely equipped for performance testing, special instrumentation including additional air-speed indicators and altimeters, engine instruments, fuel flowmeters, and air thermometers. Two of the Ansons are also fitted with trailing static tube installations for the investigation of stalling characteristics. The Dove and one Anson are fitted with control angle and control force indicators, sideslip indicators and accelerometers for the investigation of aircraft stability. Provision is made for the automatic recording

Airborne electronic equipment for the measurement of undercarriage loads. This equipment was designed and built by second-year students

by cine camera of any instruments used in tests where visual observation is impossible.

The Dove is fitted to carry six students at once, in addition to the pilot and one other member of the teaching staff. The instrumentation is so arranged that each pair of students has a complete instrument panel, including all the test instruments. Owing to difficulties of space and arrangement, this could not be done in the Ansons, where it is possible to carry only four students, and the instruments are arranged so that each student reads one or two test instruments, and their readings are combined to give a complete set. The instrumentation is constantly being modified as new equipment becomes available, and at the time of writing it is hoped to fit a torquemeter to the Dove engines in the very near future.

Research by students or staff is car-

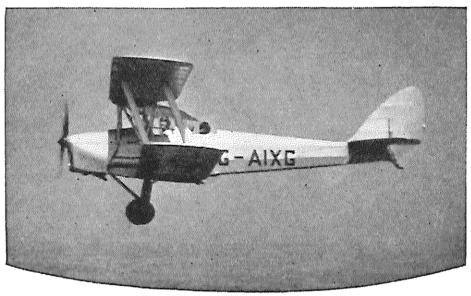
Pitot-head comb fitted to trailing edge of Anson wing; this is used for measuring the drag of an aerofoil section

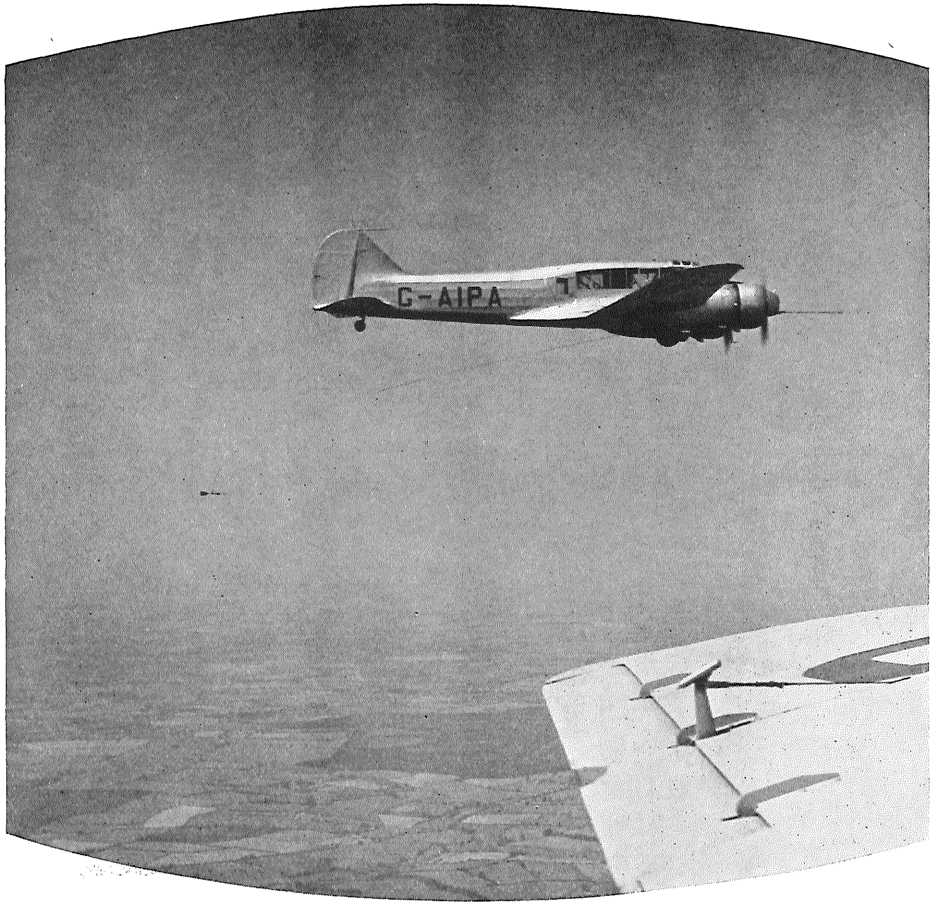
ried out on the aircraft most appropriate for any specific purpose.

THE AIRFIELD

The airfield, which is licensed for public use, has two 2,000-yard runways with good approaches, and one of 1,100 yards. For light aircraft and gliders a grass landing run is in use, demarcated in the standard manner.

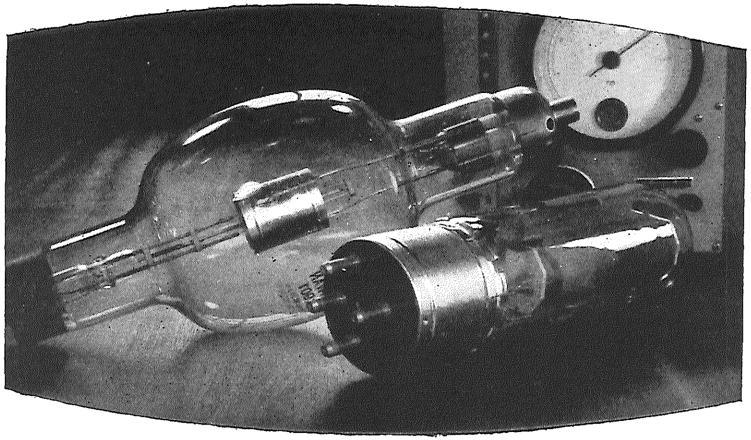
A full Air Traffic Control Service is in operation giving day and night facilities. Flying is controlled by VHF R/T. Direction-finding facilities in the form of VHF/DF and MF radio beacon are available. There is an SBA installation for instrument approaches.





(LEFT) *College Tiger Moth aircraft, used for ab initio flying training available in the Department*

(ABOVE) *Anson aircraft with trailing static head used for investigation of stalling characteristics*



RADIO & ELECTRICAL SECTION

* FIRST YEAR

CIRCUIT THEORY

CIRCUIT ELEMENTS L. C AND R. ALTERNATING AND TRANSIENT CURRENTS AND VOLTAGES. NETWORKS. THERMIONIC VALVES. VALVE AMPLIFIERS AND SPECIAL CIRCUITS. THE CATHODE RAY TUBE.

RADIATION AND AERIALS

NATURE, PROPERTIES AND PROPAGATION OF RADIO WAVES. DIPOLE AERIALS, ARRAYS. SLOTS, MIRRORS AND APERTURES.

TRANSMISSION LINES

TRAVELLING AND STANDING WAVES.
REFLECTED IMPEDANCES. MATCHING METHODS.

RADIO AND RADAR

PRINCIPLES AND PRACTICE. TRANSMITTERS, RECEIVERS, DISPLAYS. AIRCRAFT EQUIPMENTS AND INSTALLATION.

The teaching of the above subjects is supplemented by practical work in the Laboratory and demonstrations in flight.

SECOND YEAR

APPLICATION TO RESEARCH & INDUSTRIAL CONTROL

STRAIN MEASUREMENT. VIBRATION ANALYSIS. INTERVAL TIMING. STROBOSCOPY.

AIRCRAFT RADIO AND RADIO INSTALLATIONS

MINIATURISATION, SUPPRESSED AERIALS ETC.

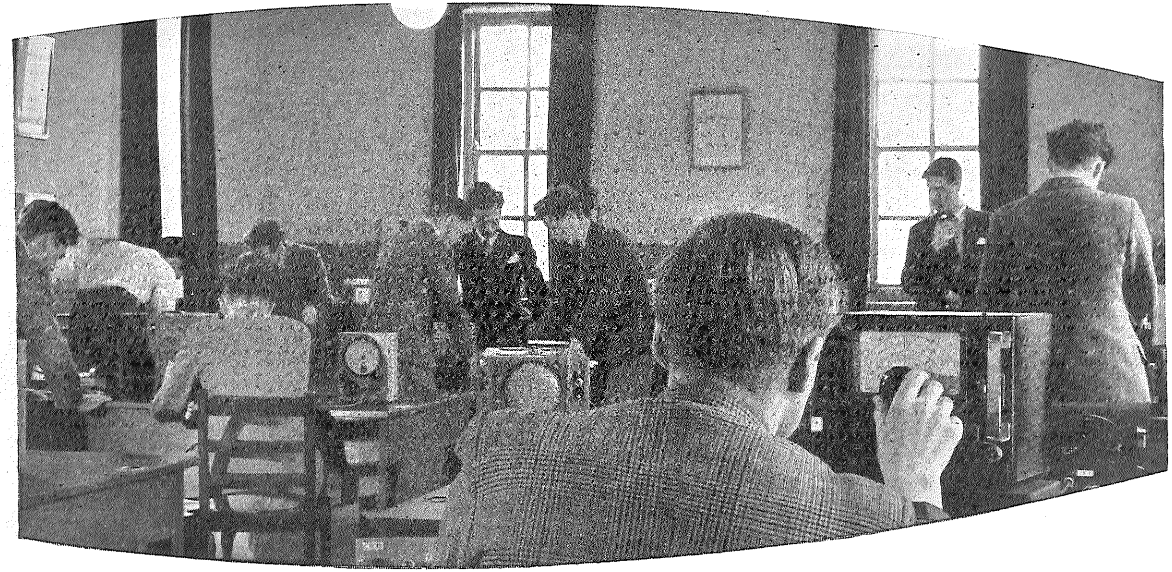
RADIO & ELECTRICAL SECTION

In recent years great advances have been made in Electronics, particularly in Radar, and these have resulted in the increasing application of electronic devices and techniques in aeronautical research and the aircraft industry. It is now accepted that an ability to make full use of such devices and techniques, together with an appreciation of their possibilities and limitations, is desirable for all concerned with aeronautics.

The course is therefore designed to familiarise the student with the contributions that electronic techniques can make to the solution of problems in all branches of aeronautics. At the same time attention is drawn to the design problems associated with the installation of radio and radar aids in aircraft arising from the need to ensure the minimum adverse effects on performance.

The first year is devoted to the basic principles and practice of the subject, while more advanced and detailed

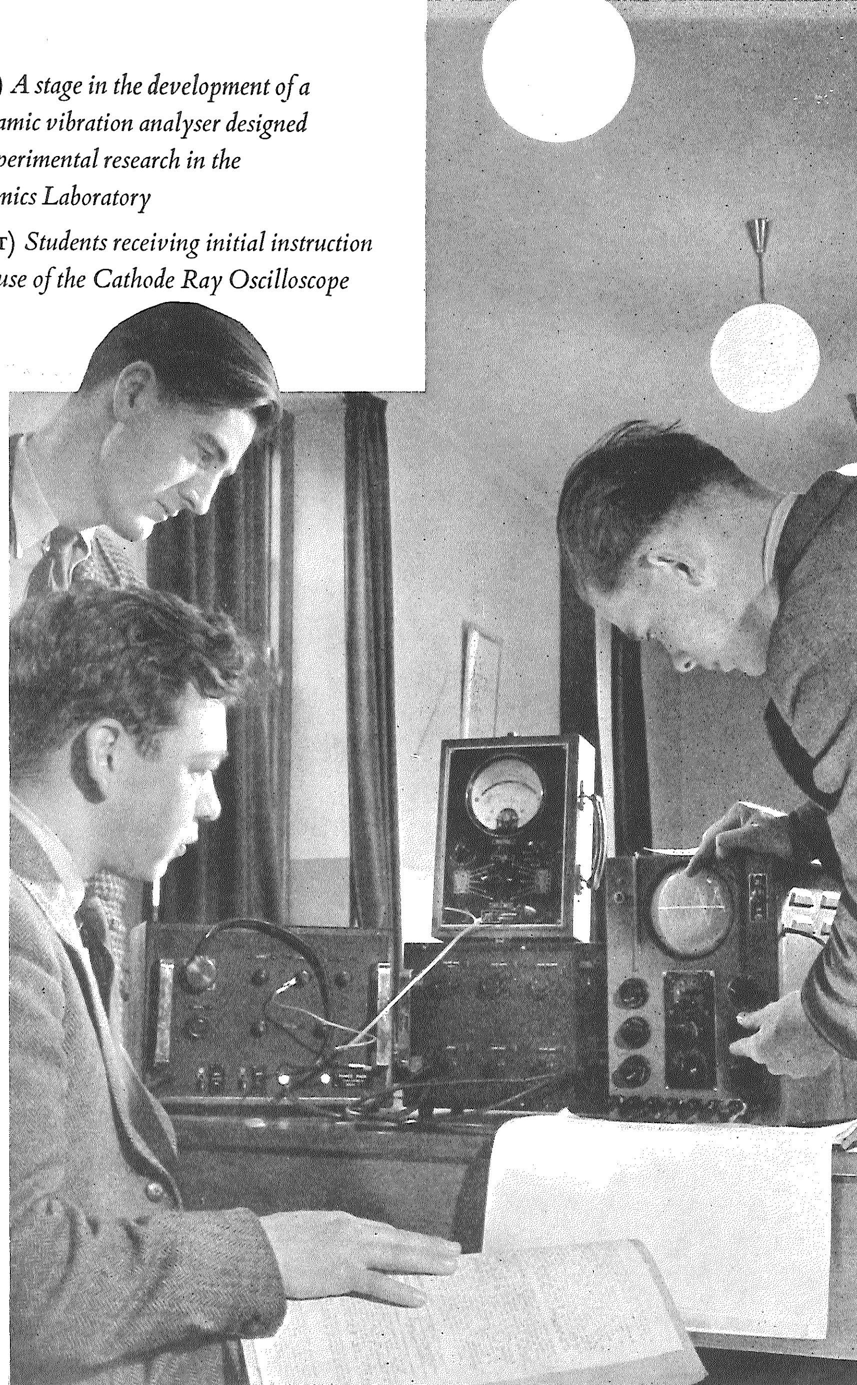
Demonstration of a typical aircraft radar installation



A view of the Circuits Laboratory showing students calibrating audio frequency amplifiers which have been constructed to their own design

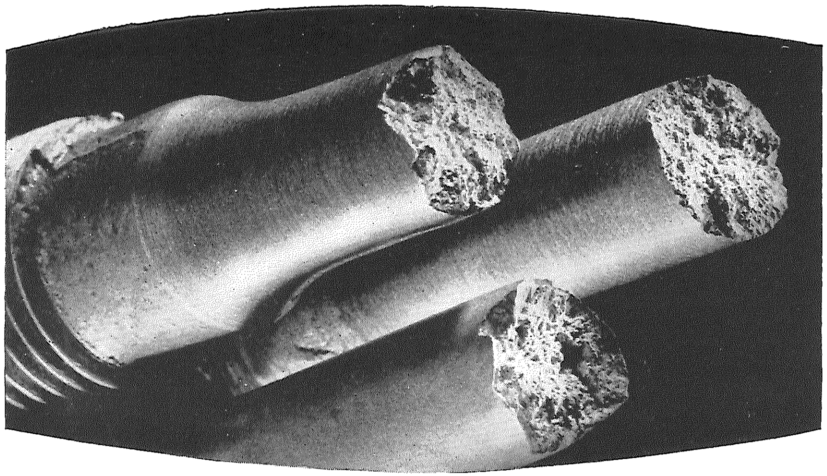
instruction is provided in the second year. In addition, short courses are arranged from time to time to meet the needs of those from industry and elsewhere requiring either refresher courses or more detailed courses dealing with particular aspects of the subject.

The equipment of the Section has been designed for research as well as for teaching, and facilities are provided for the construction of specialised items of test equipment. The Section is also responsible for the design and manufacture of the electronic equipment needed by the Departments of the College for their teaching and research work. Considerable importance is attached to this side of the Section's activities, and the advanced students are encouraged to participate in it.



(LEFT) *A stage in the development of a panoramic vibration analyser designed for experimental research in the Dynamics Laboratory*

(RIGHT) *Students receiving initial instruction in the use of the Cathode Ray Oscilloscope*



MATERIALS *and* METALLURGY

* FIRST YEAR

THEORY OF METALS. PROPERTIES OF A CRYSTALLINE AGGREGATE. DEFORMATION OF METALS. PROPERTIES OF COLD WORKED AND ANNEALED METAL. THEORY OF THE STRUCTURE AND PROPERTIES OF ALLOYS. MECHANICAL TESTING AND INSPECTION.

THEORY OF STEELS. CARBON AND ALLOY COMPOSITION; PROPERTIES AND HEAT TREATMENT. ALLOYS OF ALUMINIUM; TYPES AND PROPERTIES; THEORY AND PRACTICE OF HEAT TREATMENT; JOINING OF METALS; METHODS; TECHNICAL CONTROL AND TESTING. TECHNOLOGICAL PROCESSES FOR SHAPING METALS.

PLASTICS, WOODS, ADHESIVES.

PRINCIPLES AND INTERPRETATIONS OF A SPECIFICATION.

CORROSION OF METALS AND METHODS OF PROTECTION.

MATERIALS FOR AIRFRAMES, PISTON ENGINES AND GAS TURBINES; PROPERTIES, SPECIFICATIONS AND USES.

SECOND YEAR

LECTURES AND LABORATORY WORK TO CO-ORDINATE WITH EACH STUDENT'S PARTICULAR STUDIES.

SPECIALISTS FROM INDUSTRY AND RESEARCH ORGANISATIONS LECTURE ON RECENT DEVELOPMENTS.

MATERIALS & METALLURGY

Aeroplanes and their equipment make rigorous demands not only on the designer's skill but also on all the materials he uses. It is for this reason that the field of Aircraft Materials is at once so complex and so closely tied down to specifications of great rigidity. Every part is deliberately designed to work as near as possible to the maximum load that may safely be applied to the material.

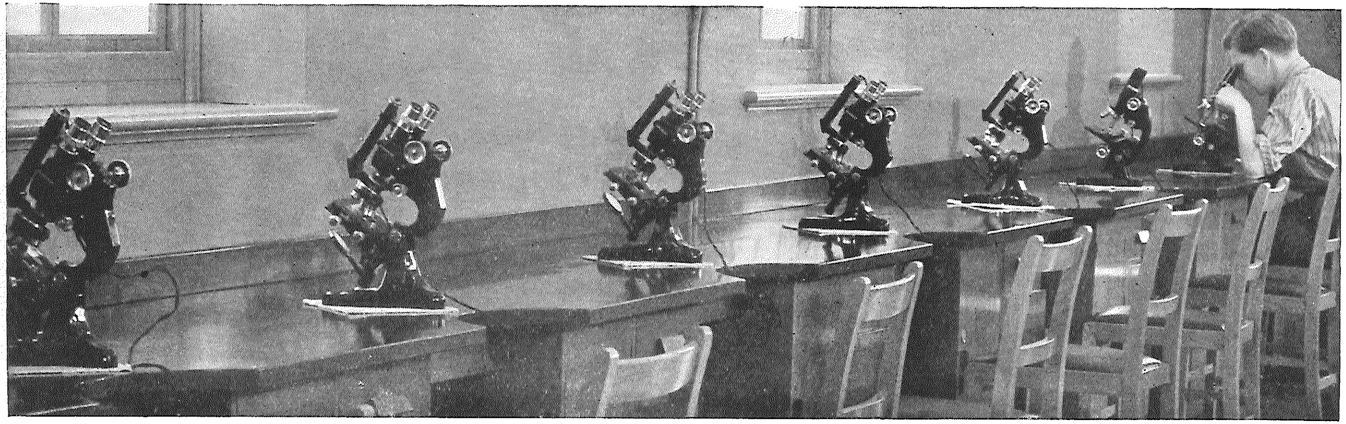
Since all the forming processes applied to metals, whether they be cast, forged, rolled, extruded, drawn or pressed, have some effect on the intrinsic properties of the original raw material, it is highly desirable that the designer should be fully aware of these changes. The exact control of technique of manufacture is essential if the optimum properties are to be realized.

While no attempt is made to provide advanced or even comprehensive training in Metallurgy a carefully directed introduction to technological practice is given.

Students are made conversant with the basic properties of the chief groups and in some detail with the most commonly used ferrous and non-ferrous aircraft materials. They are also familiarised with the language of the subject and gain experience in the principal research methods and equipment in the laboratory sessions.

The arrangement of the atom is the basis of the modern science of materials and attention is, therefore, directed to the principles fundamental to all materials, though illustrations are chosen whenever possible from the field of aircraft manufacture. Early in the course the student is made familiar with the crystallographic properties of metals and alloys by the use of the microscope. The photomicroscope, the pyrometer and X-ray photographs provide practical examples of the precise control of technological processes. From these fundamentals the student is able to correlate casting and forging with the

Heat treatment of aircraft steel. Automatic control of temperature, rate of heating and record of progress



Part of a the metallographic laboratory showing binocular microscopes for the examination of structures of aircraft alloys

technique of heat treatment and mechanical testing of ferrous and non-ferrous alloys required by a specification. The direct application of the Section's work to the problems of the Design specialist includes particular attention to the properties of sheet metal and to methods of bending, drawing and stretching. Propulsion specialists are introduced to high tensile steel alloys with special reference to proof stress and hardenability, and to high temperature creep strength testing of materials for gas turbines.

Students explore the influence of various practices under controlled conditions and prepare reports on the effects on the specimens. The results of such practical tests and all photomicrographs thus obtained are circulated to all students to widen their experience in those examples not personally done.

The course includes a survey of the latest literature with discussions on the probable development of new methods and materials.

All the laboratories are equipped with modern apparatus selected to illustrate the most recent practices in industry, and carefully chosen to illustrate principles rather than detailed techniques.

A preparation laboratory and etching

facilities for microspecimens, with equipment for mechanical and electrolytic polishing.

A microscope laboratory, containing Vickers projection microscope with phase contrast effects, Busch metallograph, binocular and monocular bench microscopes, with a full range of objectives. A separate Busch camera is used for photomacrography.

An inspection laboratory equipped for crack detection by the chalk, fluorescent and Magnaflux methods.

An industrial processes laboratory with:

A foundry containing furnaces of recuperatively fired coke and electric high-frequency types;

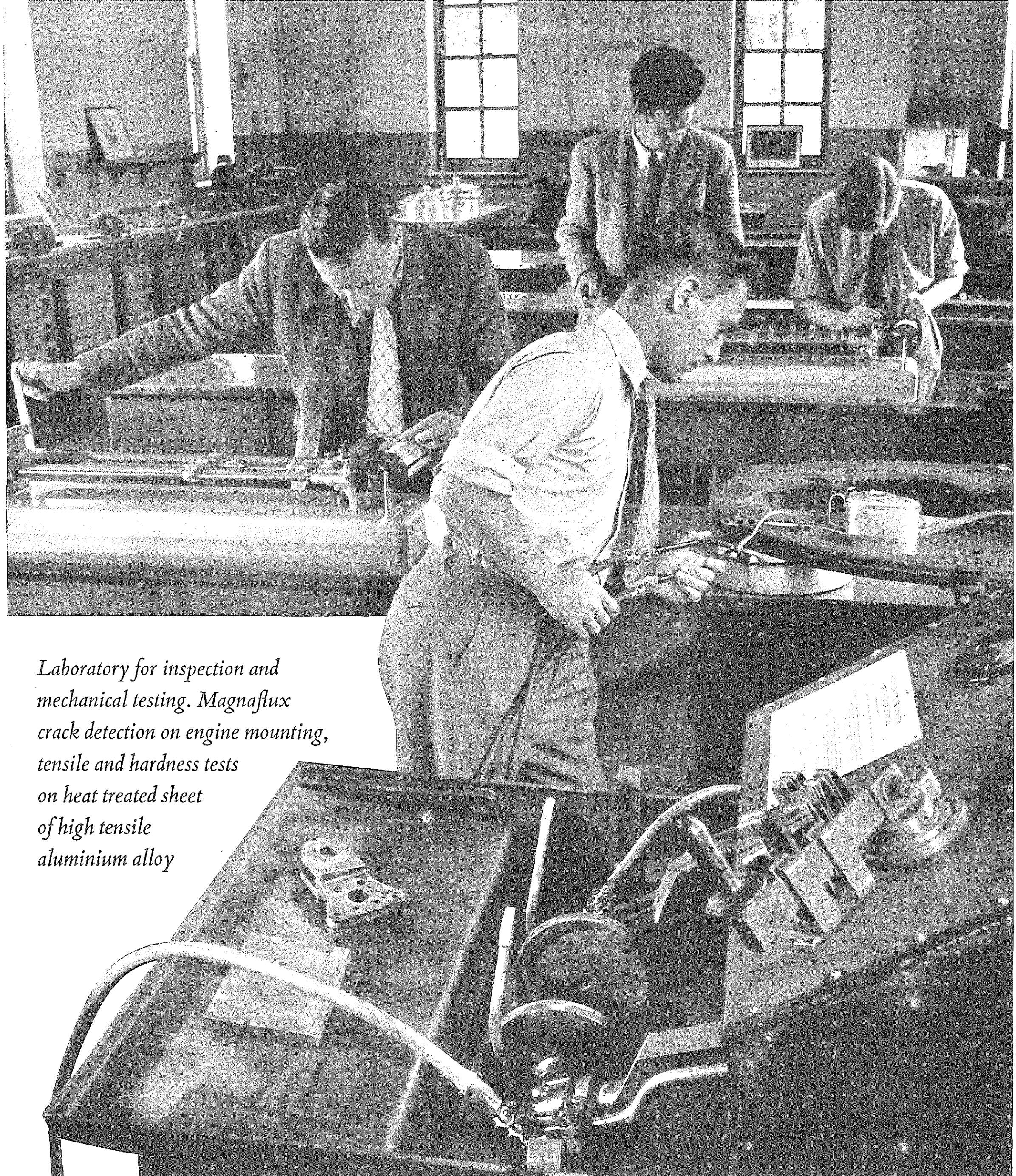
A heat treatment and forging section containing a wide range of modern furnaces.

An electrodeposition section containing degreasing plant, anodic treatment, cadmium plating and metallisation.

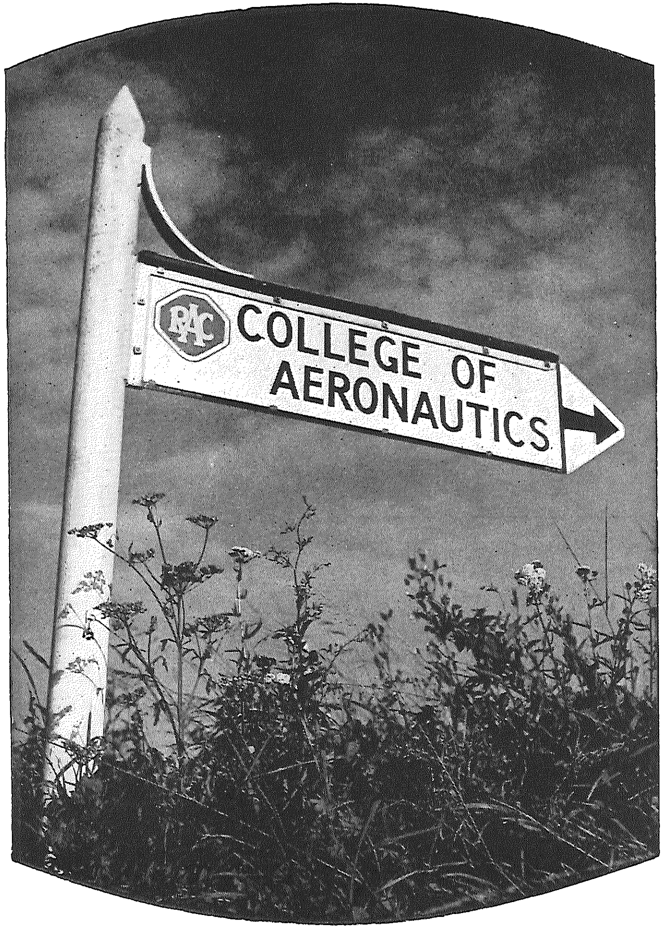
A press shop containing various forms of power and hydraulic presses.

A laboratory for mechanical testing, with Brinell, Rockwell, Vickers Pyramid for hardness, and other equipment for tensile, compression, impact, fatigue and creep tests.

A small laboratory for the experimental study of the corrosion of aircraft materials.



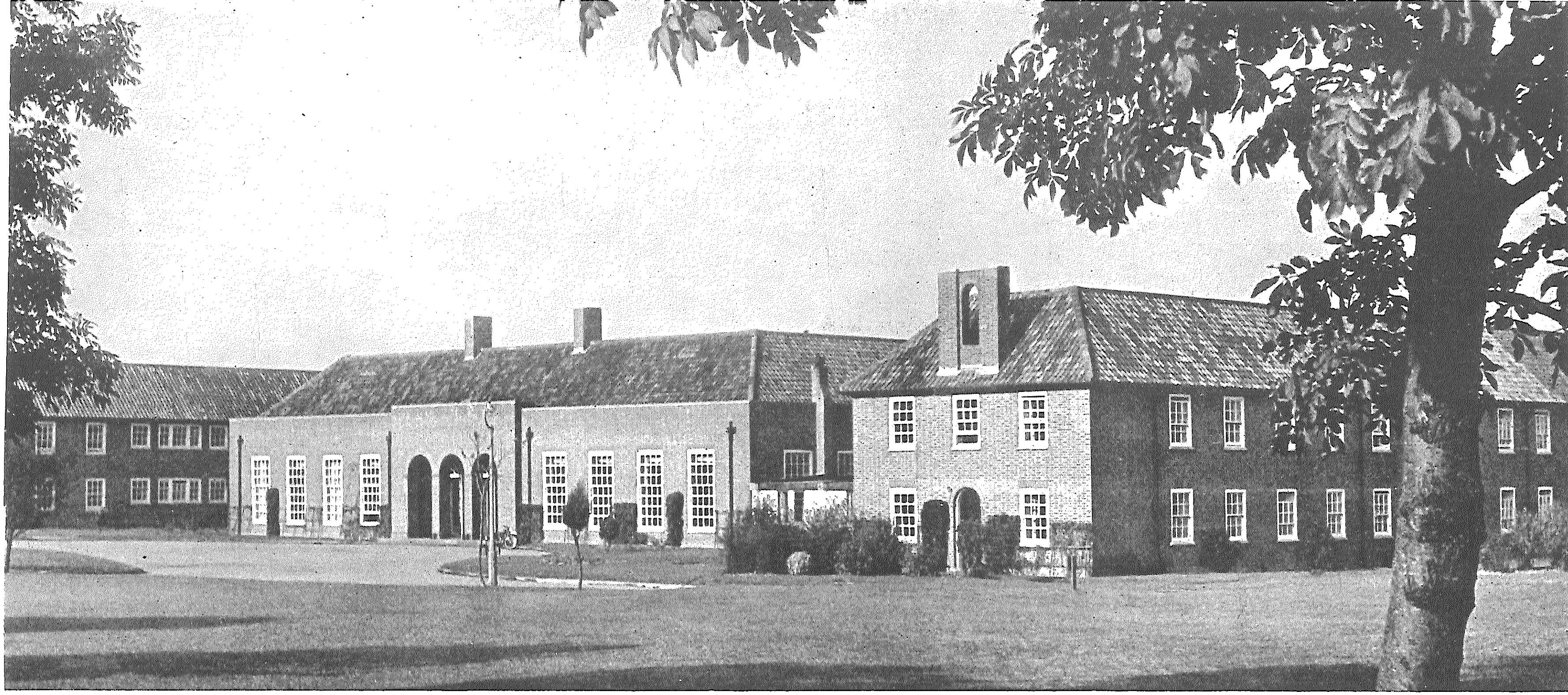
Laboratory for inspection and mechanical testing. Magnaflux crack detection on engine mounting, tensile and hardness tests on heat treated sheet of high tensile aluminium alloy



THE COLLEGE

The College of Aeronautics is situated about fifty miles north-west of London and ten miles south-west of Bedford, within easy reach by road and rail of London and other centres. It lies in a country district near the village of Cranfield, on the Bedfordshire side of the border between that county and Buckinghamshire. Bedford is the nearest town and the most convenient railhead: a regular bus service operates between Bedford and the College.

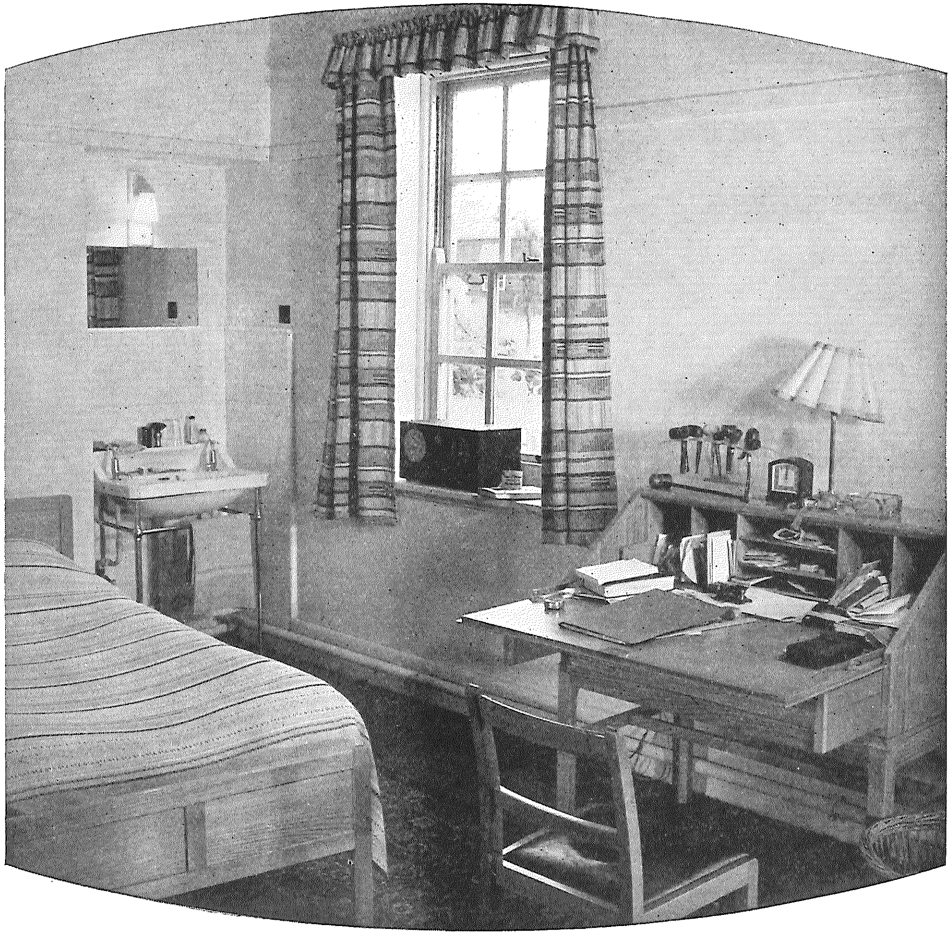
Students are normally resident in the College and are provided with a study-bedroom each. There are at present two Halls of Residence, Mitchell Hall in which first-year students are accommodated and Lanchester Hall for those in their second year. Meals are taken in Hall, and large, comfortable Common Rooms provide ample accommodation for students to meet in a congenial atmosphere.



Above: VIEW OF LANCHESTER HALL. *Below, left:* LIBRARY AND SENIOR COMMON ROOM. *Below, right:* GENERAL VIEW OF COLLEGE

Each Hall is equipped for various indoor games and has a licensed club bar.

The pressure of work necessary to fulfil the high aims of the College leaves none too much time for relaxation. Nevertheless, it is fully realised that uninterrupted specialised study is not education and the development of cultural and social activities is given full encouragement as an essential complement to the academic work. There are, for instance, a flourishing amateur dramatic society and a music circle amongst the more popular cultural organisations. There are several active clubs for those who have particular interests in various forms of scientific and technical thought. On the social side, dances and social events are held on appropriate occasions at which the students and the staff, together with their friends and acquaintances, gather together for their mutual enjoyment. The College is, in fact, very much a



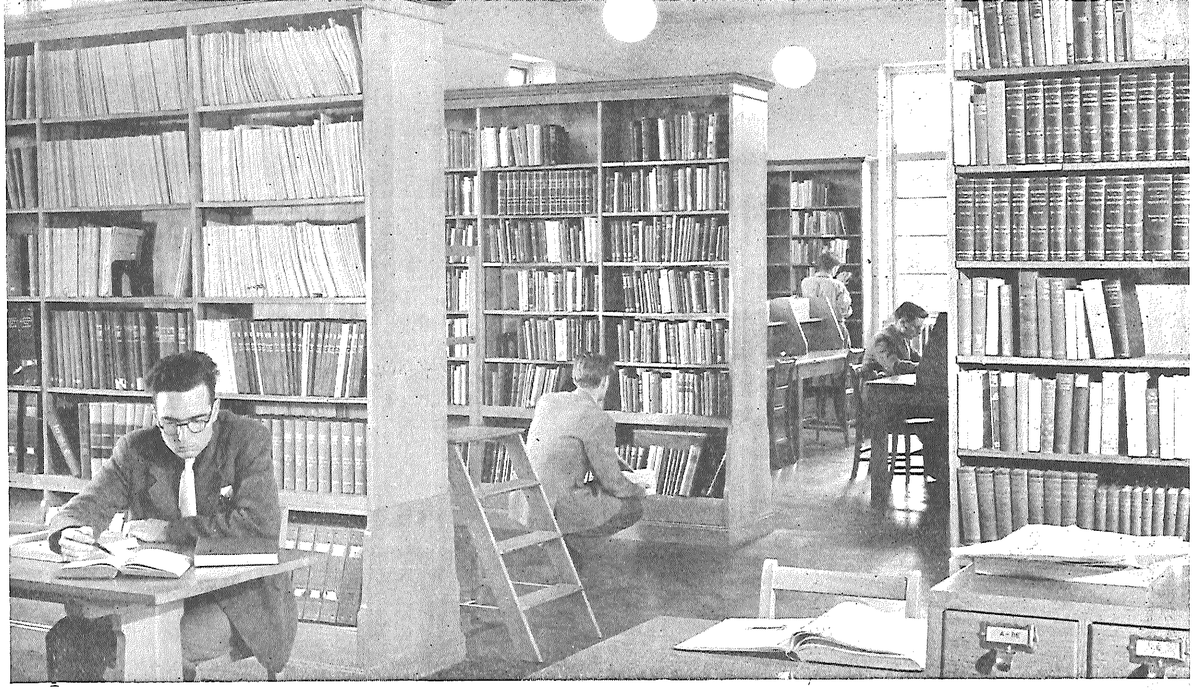
Interior of a student's study-bedroom in Lanchester Hall

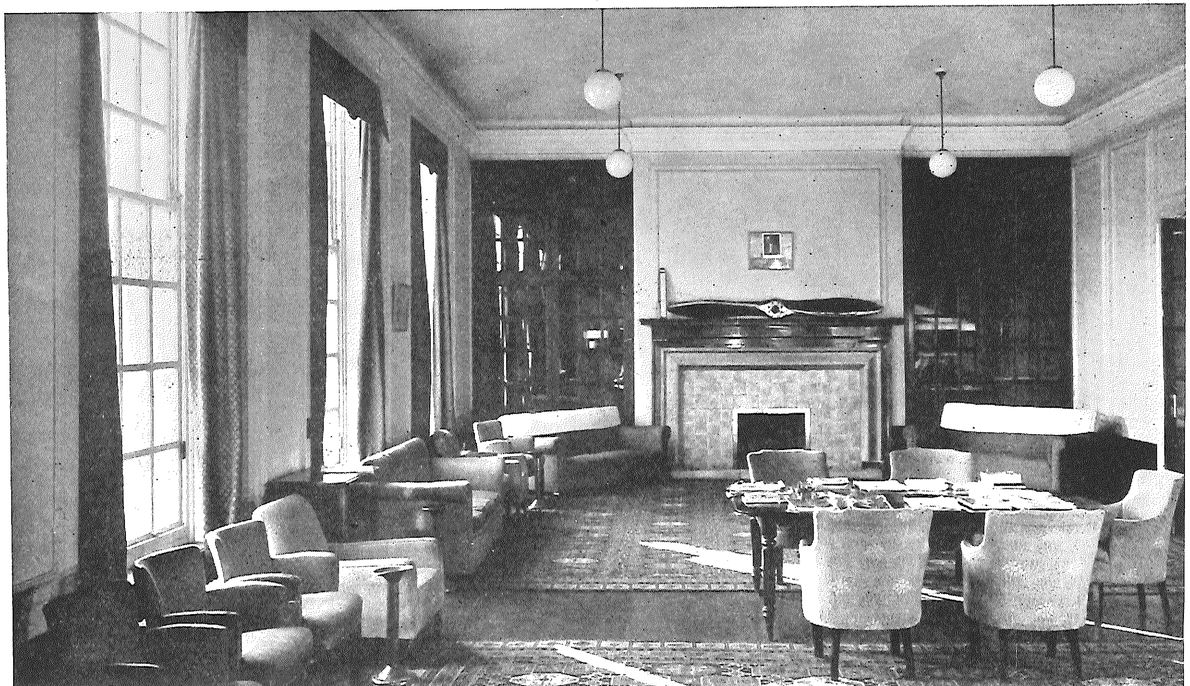
self-contained community and this has an important bearing on the character and spirit of College life. The Students' Society, which takes care of students' affairs, plays a major part in these activities.

The College library has a first-class selection of technical and scientific books, reports and periodicals and, in addition, contains a section devoted to literature, biography and other subjects of general interest.

Excellent facilities exist for most types of outdoor sport. Rugby, soccer, hockey, cricket and tennis are, for instance, fully provided for and the prowess of the Students' Society has made the College a recognised force in the sporting activities of the district.

Entry to the two-year course is made at the beginning of the academic year; later





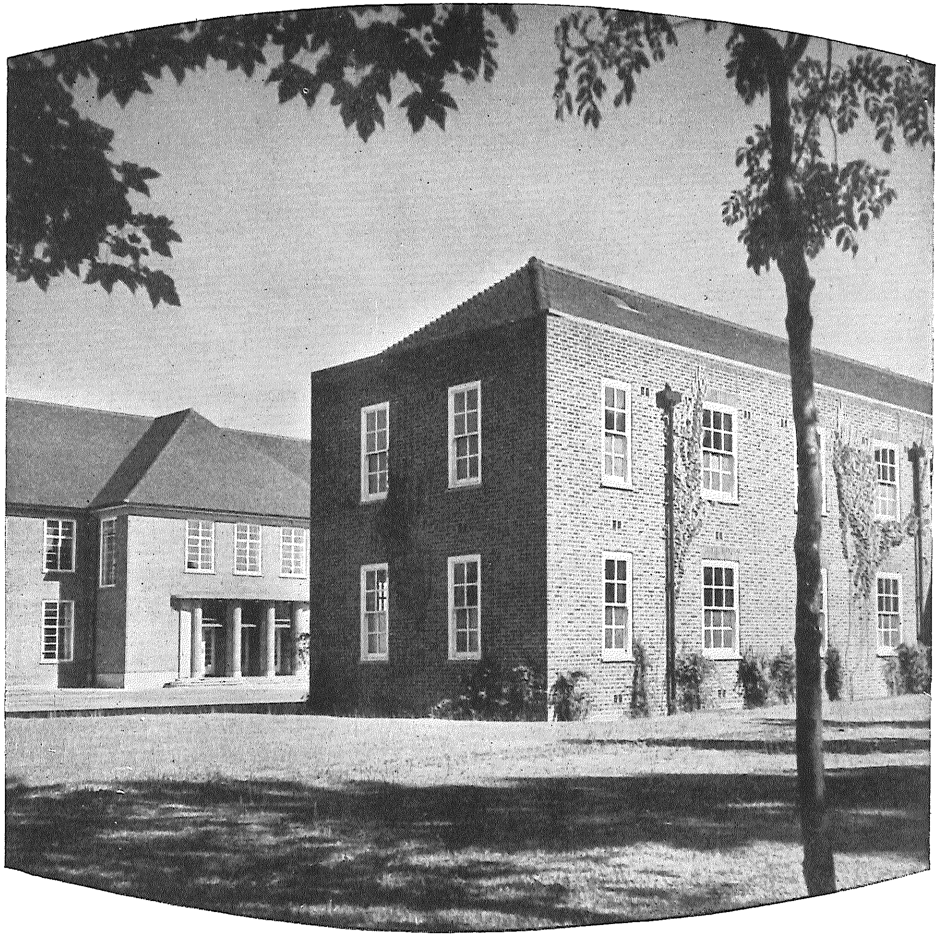
(ABOVE) *The Library*
(BELOW) *The Students' Common Room in Lanchester Hall*

entry may be permitted but only under exceptional circumstances. The academic year normally commences in October and ends in June.

Candidates for admission must complete the appropriate Form of Application, which can be obtained from the Registrar on request, and it is advisable to do this not later than June of the year in which admission is desired and preferably earlier. Registration of successful candidates is normally effected when the decision of the Board of Entry is announced.

The Registrar is always ready to answer inquiries from anyone interested who would like more specific information than can be given in this book.

Every effort is made by the College staff to help students to find appropriate employment after completion of their course.



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